Overcurrent Protection (2014 NEC) (Homestudy)

Montana Electrical License

The key sections of Article 240 will be discussed. Overcurrent protection for panelboards, appliances, motors, motor compressors, transformers, and fire pumps will also be included. The requirements for ground-fault protection for personnel and arc-fault circuit-interrupter protection are presented.

Course# MTEL14031 4 Industry Related Credit Hours $55.00

This course is currently approved by the Montana State Electrical Board under course number MTEL14031.

Completion of this continuing education course will satisfy 4.000 credit hours of course credit type 'Industry Related' for Electrical license renewal in the state of Montana. Course credit type 'Industry Related'. Board issued approval date: 8/5/2014. Board issued expiration date: 8/1/2016.

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Overcurrent Protection (2014 NEC) (Homestudy) - MT

Overcurrent Protection

Question 1: 240.1 Overcurrent Protection. Scope. Informational Note.

Question ID#: 10460.0

This Informational Note gives a one sentence statement about the purpose of overcurrent protection in electrical systems. It says: ***Overcurrent protection for conductors and equipment is provided to open the circuit if the current reaches a value that will cause an excessive or dangerous temperature in conductors or conductor insulation.***

The purpose of overcurrent protection is to prevent the insulation on conductors from being damaged.

Overcurrent protection is about protecting conductors and conductor insulation. If the conductor insulation gets overheated it will get brittle, crack, or fall off. If that happens then an electrical enclosure or raceway can become energized and someone can get shocked or killed. The purpose of overcurrent protection is to prevent this from happening.

Of course another important purpose of overcurrent protection is to isolate the electrical fault from the rest of the system and protect equipment, but as stated here, the main purpose of fuses and circuit breakers is to protect wires. Continued operation of electrical distribution systems depends on the integrity of conductor insulation. Wire size (current-carrying capacity) and overcurrent protection are matched so if the current on a conductor increases to the point where the insulation is being damaged, the overcurrent device will de-energize the circuit and protect the conductor.

Question 1: What is the main purpose of overcurrent protection?

A: To prevent the copper or aluminum in a conductor from melting.
B: To prevent voltage drop on long runs of copper conductors.
C: To prevent more than a single device from being connected to a branch circuit.
D: To protect the insulation on conductors and prevent it from overheating.

Question 2: 110.9 Interrupting Rating.

Question ID#: 10461.0

The interrupting rating of a circuit breaker is how much fault current it can safely withstand without becoming a hazard.

Overcurrent devices like circuit breakers and fuses are rated according to their trip setting. They are also classified according to their interrupting rating.

The interrupting rating of a device is the amount of current it can take without blowing up. Most branch circuit type breakers have an interrupting rating of 10,000 amps. This means the circuit breaker can withstand that much fault current without causing an explosion.

If a 20 amp circuit breaker took a 10,000 amp fault it probably could not be put back in service, but the interrupting rating does not mean the device has to ever work again. It just means the breaker cannot explode and create a hazard to anyone in the area. The definitiion of Overcurrent Protective Device, Branch-Circuit in Article 100 rrequires that the minimum interrupting rating for branch circuit overcurrent protective devices be not less than 5,000 amperes.

Whenever overcurrent devices are exposed to current levels above their interrupting rating the arc flash and arc blast pose a serious threat to electrical workers. It is very important to match the interrupting rating of overcurrent devices to the available short circuit current to protect equipment and personnel.

If the utility company installs larger capacity transformers, or if a distribution system is expanded and enlarged, it is possible the short circuit current available at the terminals of fuses and circuit breakers is greater than the interrupting rating of those devices. This can be a very dangerous situation and is a clear Code violation.

Question 2: The available short circuit current at the terminals of a circuit breaker is 15,000 amps. The interrupting rating must be:

A: A minimum of 10,000 amps.
B: Selected to protect the insulation on the conductors.
C: Twice the rating of the available short circuit current.
D: A minimum of 15,000 amps.

Question 3: 110.10 Circuit Impedance and Other Characteristics.

Question ID#: 10462.0

If a major fault occurs in an electrical system, more than just the overcurrent devices are affected. High levels of short-circuit current can damage bus bars, disconnects, panelboards and other electrical equipment. The short circuit ratings of equipment must be coordinated so if there is a fault anywhere on the system there will not be massive damage to any component.

The circuit protective device(s) must clear a fault without allowing the high levels of current through which would cause damage to circuit components.

The circuit components must be built strong enough to withstand large short-circuit currents. The amount of current they can pass without extensive damage is their short-circuit rating. The short circuit current rating of electrical equipment, such as a control panel or panelboard is limited to the lowest rated individual component in the enclosure.

Part of the job of overcurrent devices is to limit the amount of let-through fault current to keep the level of current within the short circuit ratings of each downstream component in the system.

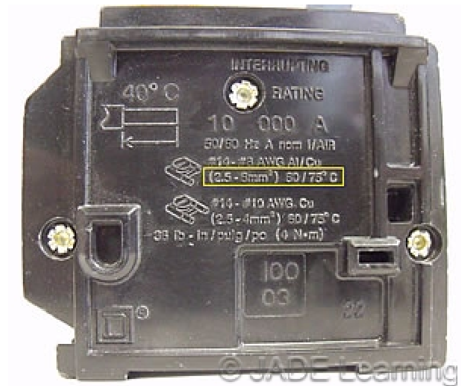
Equipment, disconnects, and busduct all have short circuit ratings which should not be exceeded.

Question 3: A distribution system has an equipment section with the following short circuit ratings: busbars 100,000 amps; disconnects 75,000 amps; switches 60,000 amps. The maximum amount of allowable short circuit current on this system is:

A: 100,000 amps.
B: 75,000 amps.
C: 60,000 amps.
D: 10,000 amps.

Question 4: 110.14(C) Temperature Limitations of Terminals.

Question ID#: 10463.0



The temperature rating of the wire must be equal to or greater than the temperature rating of the terminal. A 60/75 degree rating can be rated at 75 degree C.

Circuit breakers and fuseholders have terminals to attach wires to the circuit breaker or fuseholder. The overcurrent device is the beginning of the branch circuit or feeder and there must be a terminal to connect the conductor. In fact, a circuit breaker is an assembly which includes the tripping mechanisms and the means to attach a conductor. A fuseholder is also an assembly which is made to hold a fuse of a certain voltage and current rating and the means to connect a conductor. If the terminal gets overheated it can adversely affect the operation of the fuse or circuit breaker.

To prevent overheating at the terminals, Section 110.14(C) requires the temperature rating used to determine conductor ampacity to equal or exceed the temperature rating of any connected termination in the circuit. The UL marking guide for Molded Case Circuit Breakers explains: ***All circuit breakers rated 125A or less are marked for use with 60 degree C, 60/75 degree C, or 75 degree C only wire. This marking indicates the proper wire size for termination in accordance with Table 310.15(B)(16) of the NEC. It is acceptable to use wire with a higher insulation rating if the ampacity is based on the wire temperature rating marked on the breaker.***

Most terminals today are marked 60/75 degree C or 75 degree C. This means that whatever the rating of the overcurrent device, the 75 degree C rating of the wire (taken from Table 310.15(B)(16) can be used to select the conductor. If the terminal is not marked, or the terminal is marked for 60 degree C conductors, the ampacity of the conductor must be selected from the 60 degree column of Table 310.15(B)(16).

Example #1: If there were 3 current-carrying No. 6 AWG, THHN, copper conductors installed in a raceway in an 86 degree F (30 degree C) ambient temperature, what is the ampacity of the conductors when connected to a breaker marked with a terminal temperature rating of 60/70 degree C like the one in the illustration?

The THHN conductor is in the 90 degree C column of Table 310.15(B)(16). According to the table, the 90 degree C column indicates the ampacity of the No. 6 conductor is 75 amps. However, because the terminal temperature rating of the breaker is 60/75 degrees C, the conductor's ampacity is limited to 65 amps which is indicated in the 75 degree column. If the breaker was marked with a 60 degree rating, the ampacity of the No. 6 AWG THHN copper conductor would be limited to 55 amps.

Example #2: What is the smallest THWN-2 copper conductor that can be used for a 200 amp load, when the conductor is connected to a 200 amp breaker with terminals marked 75 degrees C?

In table 310.15(B)(16) from the 75 degree column select the 3/0 conductor which is the smallest conductor that has a 200 amp or greater rating. Even though the THWN-2 conductor is in the 90 degree column, because the breaker's terminals are marked for 75 degree C, the conductor's ampacity is limited to thye ampacity in the 75 degree column. When connected to 75 degree C terminals, a 3/0, THWN-2, copper conductor is not permitted to carry the 225 amps indicated in the 90 degree C column.

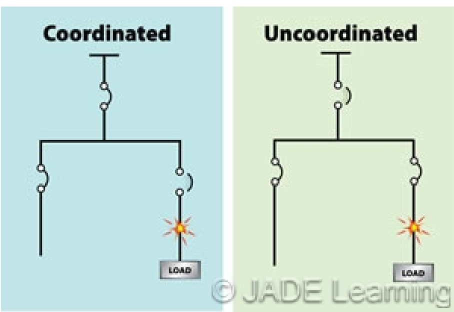
In general, the 90 degree C ampacity rating for conductors is only used in derating for ambient temperature and when there are more than 3 current carrying conductors in conduit.

Question 4: What is the minimum size THHN, 90 degree C conductor for a 100 amp circuit breaker with 75 degrees C rated terminals?

A: No. 3 AWG cu.
B: No. 2 AWG cu.
C: No. 1 AWG cu.
D: 1/0 AWG cu.

Question 5: Article 100 Definitions: Coordination (Selective).

Question ID#: 10464.0



In a coordinated electrical system the overcurrent device immediately ahead of the fault will de-energize the circuit. In uncoordinated systems a feeder breaker or even the service breaker could trip on a branch circuit fault.

Coordination (Selective). ***Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the selection and installation of overcurrent protective devices and their ratings or settings for the full range of available overcurrents, from overload to the maximum available fault current, and for the full range of overcurrent protective device opening times associated with those overcurrents.***

Good electrical coordination prevents upstream breakers from tripping before the downstream breaker has sufficient time to clear the fault.Â If an electrical distribution system is coordinated, a fault on a branch circuit breaker will not trip the feeder breaker.Â The fault is isolated to just a small part of the system.Â The overcurrent device immediately upstream from the fault takes the affected branch offline, and no other part of the system is involved.

Systems may be coordinated according to howÂ large the fault is or how long the fault lasts.Â In either case, the upstream breaker has to hold until the downstream breaker can clear the fault.Â For example, if time is used to coordinate the system, the time delay on the upstream breaker must be longer than the maximum amount of time the downstream breaker takes to clear the fault. When upstream overcurrent devices trip before downstream devices, it usually is because the downstream breaker did not trip fast enough. When this happens, large parts of the system will lose power because the fault is not localized by the downstream device.

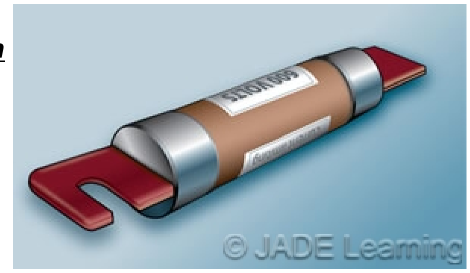
Question 5: In a coordinated system of overcurrent devices:

A: The upstream device trips before the downstream device.
B: The downstream overcurrent device nearest the fault is the first to trip.
C: The feeder breaker trips before the branch circuit breaker.
D: The time delay for the upstream device is less than the time delay for the downstream device.

Question 6: 240.2 Definitions: Current-Limiting Overcurrent Protective Device.

Question ID#: 10465.0

A Current-Limiting Overcurrent Protective Device is: ***A device that, when interrupting currents in its current-limiting range, reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.***



A current-limiting device acts within the first half-cycle to de-energize the circuit before the current can reach its maximum value.

Many large commercial and industrial electrical systems have enormous amounts of available fault current. Overcurrent devices with high enough interrupting ratings to deal with huge levels of available fault current are very expensive. It is much more practical to reduce the level of available fault current at a device, rather than buy overcurrent devices with high interrupting ratings that can handle the fault currents.

A current-limiting fuse is a fast fuse. It can act within a half cycle to cut off the destructive fault currents before they reach their maximum intensity. A short circuit or ground fault will build to its highest level within 2 or 3 cycles. The fault current will rise to the maximum level that the electrical source can pump into the fault. The fault current will stay at these high levels until something gives or burns loose. If action is not taken before the currents reach peak values in the first half cycle then the maximum available fault current will flow through the system components.

Downstream overcurrent devices are permitted to have interrupting ratings that match the let-through current of the current-limiting device. For example, if a system has 100,000 amps of available fault current, but a current-limiting fuse limits the fault current to 10,000 amps, downstream components with 10,000 amp interrupting ratings can be used.

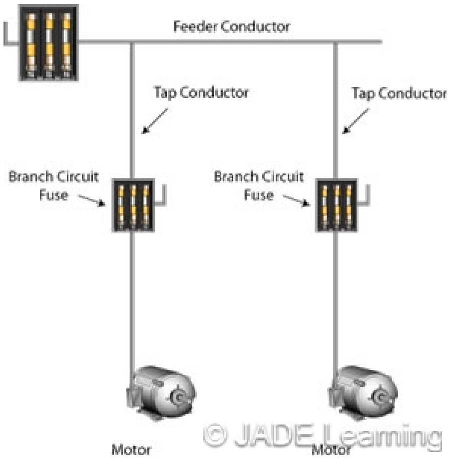
Fuseholders for current-limiting fuses must have rejection clips to prevent a current-limiting fuse from being replaced with a non-current-limiting fuse.

Question 6: A current-limiting fuse:

A: Can limit the amount of let-through current to values less than a standard fuse.
B: Has a longer time delay than a standard fuse.
C: Is used more for circuit overloads than short circuits.
D: Limits let-through currents to the maximum amount of available fault current.

Question 7: 240.2 & 240.21 Definitions: Tap Conductors.

Question ID#: 10466.0



A tap conductor has overcurrent protection in excess of the value of the conductor.

The Code definition is: ***As used in this article, a tap conductor is defined as a conductor, other than a service conductor, that has overcurrent protection ahead of its point of supply that exceeds the value permitted for similar conductors that are protected as described elsewhere in 240.4.***

Tap conductors are exceptions to the rule that conductors must be protected at the point where they are connected to an electrical source (240.21). Tap conductors are an important exception because the main purpose of Article 240 is to protect conductors.

The limited overcurrent protection a tap conductor has is from the upstream feeder or branch circuit breaker, but the upstream breaker has been sized to protect the feeder or branch circuit, not the tap. Because tap conductors do not have the standard overcurrent protection, they are more dangerous than protected wires, and there are important Code rules for the size, length, and wiring method used for tap conductors.

Service conductors are not included in the definition of tap conductors because service conductors have their own rules. Service conductors may be tapped (230.46), but the ampacities of the tap conductors are determined by Article 230, not Article 240.

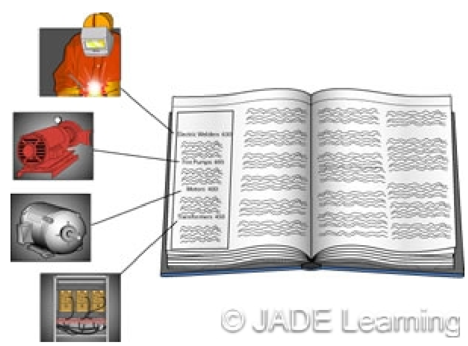
Question 7: Tap conductors:

A: Are always larger than the branch circuit conductors.
B: Are protected by the feeder fuse at their ampacity.
C: Are twice the size of the branch circuit conductors.
D: Have overcurrent protection ahead of the point of supply.

Question 8: 240.3 Other Articles: Protecting Equipment.

Question ID#: 10467.0

Article 240 is about protecting conductors, but some equipment and associated conductors are covered by other Articles. The requirements for overcurrent devices used to protect specific types of equipment are not found in article 240. Rules for protecting equipment are found in articles that deal specifically with that type of equipment. For example, the requirements for overcurrent protection of transformers is in article 450 not in article 240. The list of Code Articles in Table 240.3 is a reference for users to consult when making sure equipment as well as conductors are protected against overloads, short circuits, and ground faults.



Section 240.3 lists other Articles that should be consulted when protecting equipment like welders, fire pumps, motors, and transformers.

The plant manager or building owner will not be pleased if their million dollar machine is destroyed but the wires feeding the machine are protected. The equipment articles need to be consulted so that the system of overcurrent protection safeguards all of the electrical components: wires, panelboards, luminaires, switches, and equipment.

Wires are best protected as close to their ampacities as possible. If a load draws 63 amps the best protection is as close to 63 amps as possible, but overcurrent protection for equipment must often take into account other factors like inrush current and continuous loading. Also, if an equipment manufacturer requires a specific size fuse or circuit breaker, then that is the size which must be used (110.3B).

Question 8: You are installing a branch circuit for a large motor. According to Table 240.3, which lists other code articles that have the requirements for specific pieces of equipment, which Code article will have the requirements for protecting the motor circuit?

A: Article 240.
B: Article 430.
C: Article 210.
D: Article 250.

Question 9: 240.4 Protection of Conductors.

Question ID#: 10468.0

If the ampacity of a conductor is reduced because there are more than 3 current-carrying conductors in a raceway, the conductor must be protected at its reduced ampacity.

The general rule is that conductors must be protected according to their ampacities as determined by section 310.15. What does section 310.15 say about selecting conductors?

- Voltage drop: distance is not taken into account.
- How much current a conductor can carry is affected by the ambient temperature and the
- For dwelling units that have single-phase services rated from 100 to 400 amps, the servi
- Conductor ampacity is selected from tables 310.15(B)(16) - 310.15(B)(21) unless calcula
- The ampacity of conductors in conduits on rooftops exposed to sunlight must be adjusted

Conductors are protected according to their ampacities, even if they are derated. For example, if 4-6 current-carrying conductors are in conduit their wires can only carry 80% of the values listed in Table 310.15(B)(16). A No. 3 AWG Type THW CU wire can carry 100 amps. If it is derated to 80% it can only carry 80 amps. The maximum overcurrent protection for the No. 3 AWG CU conductor is 80 amps, not 100 amps.
Another example: A No. 4 AWG Type THW CU wire can carry 85 amps. If it is derated 80% it can only carry 68 amps. The maximum overcurrent protection that could be used is 70 amps, not 80, 85, or 90 amps. Conductors must be protected according to their ampacities. Derating a conductor gives it a new maximum ampacity. The conductor must be protected at that new ampacity. However, for overcurrent devices rated 800-amperes or less, section 240.4(B)(1-3) gives permission to use the next higher standard size overcurrent protective device when the conductor ampacity does not correspond with the standard rating of overcurrent protective devices listed in 240.6(A).

Question 9: A 1/0 AWG conductor can carry 150 amps. If it is installed in a raceway with 3 other current-carrying conductors it must be derated to 80% of its current-carrying capacity. What is the maximum size of the overcurrent protection allowed?

A: 100 amps.
B: 110 amps.
C: 125 amps.
D: 150 amps.

Question 10:   240.4(B) Devices Rated 800 Amperes or Less.

Question ID#: 10469.0

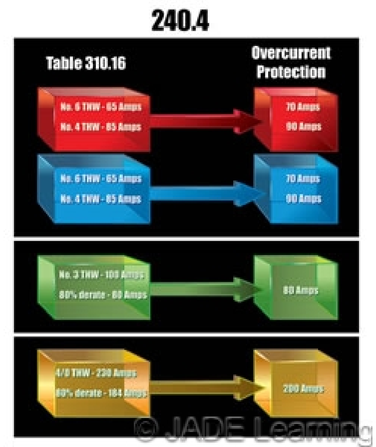
Conductors are protected according to their ampacities. However, the next higher standard overcurrent device rating can be used:

- If the ampacity of the wire does not match a standard overcurrent device rating listed in 240.6A.
- If the wires being protected are not part of a multioutlet circuit supplying receptacles.
- If the next higher size is not over 800 amps.

The conductor's ampacity must always be equal to or greater than the load. But the overcurrent protection for the wire can be selected from the next higher standard overcurrent device rating. For example, a wire rated at 65 amps can be protected at 70 amps. A wire rated at 85 amps can be protected at 90 amps. A wire rated at 380 amps can be protected at 400 amps. The wire is still considered to be protected even if the next standard size is used.

Conductors feeding a 20 amp circuit that supplies receptacles for cord-and-plug connected loads in a residential, commercial, or industrial location must be rated at least 20 amps. They could not be rated 18 amps and protected at 20 amps. Likewise, wires feeding a 15 amp receptacle circuit must be rated the full 15 amps.

Since it is impossible to predict what will be plugged into a receptacle, and very possible that receptacle circuits will be overloaded, the Code wants branch circuit wires supplying receptacle outlets to be rated at least as large as the branch circuit breaker.



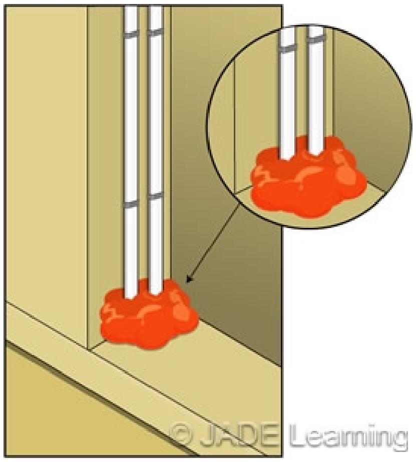
The next higher standard size overcurrent protective device can be used to protect a conductor, up to 800 amps.

Question 10:   A No. 6 AWG wire rated at 65 amps is run to a single appliance. What is the maximum standard size branch circuit breaker allowed?

A: 60 amps.
B: 70 amps.
C: 75 amps.
D: 80 amps.

Question 11: 240.4(D) Small Conductors.

Question ID#: 10470.0



Use the wire ratings from Table 310.15(B)(16) when derating conductors. OC protection is still limited to 30 amps for No. 10 AWG, 20 amps for No. 12 AWG, and 15 amps for No. 14 AWG.

Section 240.4(D) limits the overcurrent protection for No. 14 AWG copper conductors to 15 amps, No. 12 AWG copper conductors to 20 amps, and No. 10 AWG conductors to 30 amps. The ratings are well known because these wires are the most common branch circuit sizes.

It gets more confusing when using Table 310.15(B)(16), though, because the values in the table are higher than the allowable overcurrent protection permitted for small conductors by 240.4(D).

For 75Â°C conductors, Table 310.15(B)(16) rates a No. 14 AWG at 20 amps, a No. 12 AWG at 25 amps, and a No. 10 AWG at 35 amps. The higher ampacity ratings of Table 310.15(B)(16) for No. 14, No. 12, and No. 10 AWG conductors are used when adjusting the ampacity of a conductor because of ambient temperature or more than 3 current-carrying conductors in raceway. However, in general a No.14 AWG cannot be protected at more than 15 amps, a No. 12 AWG cannot be protected at more than 20 amps, and a No. 10 AWG cannot be protected at more than 30 amps, per section 240.4(D).

For example, a No. 12 AWG nonmetallic sheathed cable is used on a branch circuit that supplies receptacles. A receptacle circuit is a multi-outlet branch circuit and the ampacity of the wire must be equal to or larger than the size of the overcurrent protection.

If the NM cable is bundled with two more cables, there are 6 current-carrying conductors. If the three cables pass through an opening that is fire-stopped, the ampacity of each wire must be reduced to 80% of the value in Table 310.15(B)(16). The wire inside a nonmetallic sheathed cable is rated for 90 degrees C. The 90 degree C rating of a No. 12 conductor is 30 amps. 30 amps x 80% = 24 amps.

The circuit must still be protected at 20 amps. The point is that 240.4(D) limits the size of the overcurrent protection. If ampacity adjustment is required for a small conductor it starts with the values for conductors in Table 310.15(B)(16), not the values of small conductors in 240.4(D).

Question 11: What is the maximum size overcurrent protection for a No. 10 Type THHN conductor with an ampacity rating of 40 amps?

A: 40 amps.
B: 35 amps.
C: 30 amps.
D: 25 amps.

Question 12: 240.5 Protection of Flexible Cords, Flexible Cables, and Fixture Wires.

Question ID#: 10471.0

Like branch circuit conductors, flexible cords, flexible cables, and fixture wires are protected according to their ampacity, but the ampacity of cords, cables, and fixture wires is different than the values found in Table 310.15(B)(16) for branch circuit conductors. The current-carrying capacity for cords and cables is found in Table 400.5(A)(1) & Table 400.5(A)(2) The ampacity for fixture wires is found in Table 402.5.

The ampacity of conductors in flexible cords is selected from Table 400.5(A)(1) and (A)(2).

One important difference about protecting flexible cords, cables, and fixture wires is that supplementary overcurrent protection, such as what is often found in HID lighting, is an acceptable way to protect these types of wires.

Also, the supply cords of listed appliances and permanent and portable luminaires are considered protected when used within the listing requirements of the appliance or portable lamp. Extension cord sets are also considered protected if used within the requirements of the extension cord listing, which usually includes a maximum length of the cord.

Field assembled extension cords which are made with listed components can use 16 AWG and larger wire on 20 ampere branch circuits.

For overcurrent devices rated 800-ampers or less, section 240.4(B)(1-3) gives permission to use the next higher standard size overcurrent protective device when the conductor ampacity does not correspond with the standard rating of overcurrent protective devices listed in 240.6(A).

Question 12:   The overcurrent protection for flexible cords, cables, and fixture wires:

A: Can be provided by supplementary overcurrent protection.
B: Is required to be the same rating as the branch circuit.
C: Is required to be greater than the branch circuit that supplies them.
D: Is determined from Table 310.15(B)(16).

Question 13:   240.6 Standard Ampere Ratings.

Question ID#: 10472.0

The trip time of an inverse time circuit breaker decreases as the fault current increases.

There are two basic types of non-adjustable molded case circuit breakers:

Instantaneous trip circuit breaker: The trip time for an instaneous trip circuit breaker is the same for all levels of overcurrent.

Inverse time circuit breaker: An inverse time circuit breaker trips in less time at higher levels of overcurrent than at lower levels of overcurrent.

The standard ampere ratings for fuses and inverse time circuit breakers are: 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000 amperes. Additional standard ampere ratings for fuses shall be 1, 3, 6, 10, and 601.

If an adjustable-trip circuit breaker has an external means to change the setting, then the rating of the breaker must be the maximum possible setting. If the trip setting on an adjustable-trip breaker is protected by a removable and sealable cover over the adjusting screw, or if the equipment enclosure door is bolted shut, or if the breaker is behind locked doors which are only accessible to qualified personnel, then the rating of the breaker is permitted to be equal to the adjusted trip setting.

For overcurrent devices rated 800-ampers or less, section 240.4(B)(1-3) gives permission to use the next higher standard size overcurrent protective device when the conductor ampacity does not correspond with the standard rating of overcurrent protective devices listed in 240.6(A).

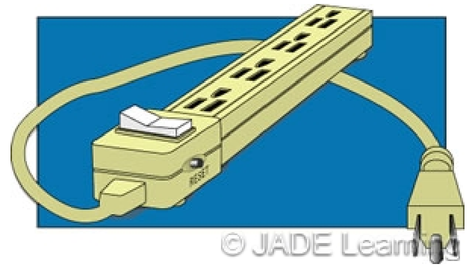
Question 13:   Two 500 kcmil conductors in parallel can carry 760 amps. The maximum rating of the standard overcurrent device protecting these conductors is:

A: 400 amps.
B: 750 amps.
C: 800 amps.
D: 1000 amps.

Question 14: 240.10 Supplementary Overcurrent Protection.

Question ID#: 10473.0

Some equipment has built-in overcurrent protection in addition to the branch circuit fuse or circuit breaker. This additional overcurrent protection is usually installed by the manufacturer and is meant to protect the individual luminaire, appliance, or piece of equipment. Much of the electronic equipment in use today has some form of protection for its internal circuitry. The purpose of supplementary overcurrent protection is to protect and extend the life of the manufacturer's equipment.



Supplementary overcurrent protection, like that used in power strips, cannot be a substitute for branch circuit overcurrent protection.

Section 240.10 says this supplementary overcurrent protection cannot be a substitute for the branch circuit protection required by Articles 210 or 240. This makes sense because there may be additional appliances or devices on the branch circuit which do not have supplementary overcurrent protection. Even if each type of equipment on the branch circuit had supplementary overcurrent protection, the conductors connecting the equipment must be protected by the branch circuit fuse or breaker.

Because supplementary overcurrent protection is not the same thing as branch circuit overcurrent protection, supplementary overcurrent protection is not required to be readily accessible. It can be behind locked or bolted covers, or installed in such a way as to not be easily replaced.

Question 14: Which of the following statements about supplementary overcurrent protection is true?

A: Supplementary overcurrent protection can be used as a substitute for branch circuit overcurrent protection.
B: Supplementary overcurrent protection must be readily accessible.
C: Supplementary overcurrent protection can not be used as a substitute for branch circuit overcurrent protection.
D: Supplementary overcurrent protection is not permitted to be used to protect internal circuits and components of equipment.

Question 15: 240.13 Ground-Fault Protection of Equipment.

Question ID#: 10474.0

Main disconnects rated 1000 amps or more must have ground fault protection for equipment for solidly grounded 277/480 volt systems.

Each building or structure's main disconnecting means rated 1000 amps or more must have ground-fault protection for equipment if the equipment is supplied by is a 3-phase, 4-wire, wye system with a voltage rating more than 150 volts to ground but not more than 1000 volts phase-to-phase.

Ground-fault protection of equipment is similar to ground-fault protection for personnel, in that it will shut the system down if there is leakage current to ground or a ground fault. The difference is that the trip point is higher in ground-fault protection of equipment than it is in ground-fault protection for personnel.

There is a requirement in 230.95 that 3-phase, 4-wire, wye building services of 1000 amps or more must have ground-fault protection for equipment if the voltage rating is more than 150 volts to ground but not more than 1000 volts phase-to-phase. The requirement in 240.13 for 1000 amp ground-fault protection applies to buildings that are supplied by feeders or branch circuits, not services. Fire pumps and continuous industrial processes do not need ground-fault protection for equipment because fire pumps supplying the sprinkler system must run even with a ground fault. If a continuous industrial process was interrupted it could be more of a hazard than starting an orderly shutdown.

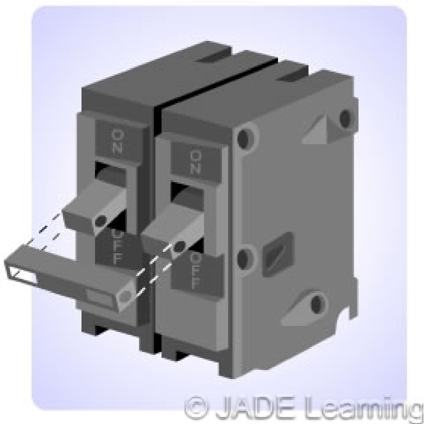
Large building disconnects at 1000 amps or more are safer with ground-fault protection for equipment. If a ground fault develops into a phase-to-phase fault, or even if a ground fault is not immediately taken offline, the disconnect is subject to severe damage which can cause fires or threaten the safety of personnel.

Question 15: In general, ground-fault protection of equipment is required:

A: For building main disconnects rated at 1000 amps or more.
B: For fire pumps and continuous industrial processes.
C: If the rating of the building disconnect is 800 amps.
D: For buildings supplied by outside transformers.

Question 16: 240.15 (A)&(B) Ungrounded Conductors.

Question ID#: 10475.0



Each ungrounded conductor in a circuit requires overcurrent protection. Two single pole circuit breakers with identified handle ties can protect line-to-line loads.

Circuit breakers or fuses must be connected in series with each ungrounded conductor. A combination current transformer and overcurrent relay are considered the same as an overcurrent trip unit.

Section 210.4(B) requires the disconnecting means for multiwire branch circuits to simultaneously disconnect all ungrounded conductors at the point where the multiwire branch circuit originates.

In single-phase grounded systems, a 2-pole breaker or two single-pole breakers with identified handle ties are required to protect line-to-line loads.

In 4-wire, 3-phase grounded systems, a 3-pole breaker or three single-pole breakers with identified handle ties are required for 3-phase loads.

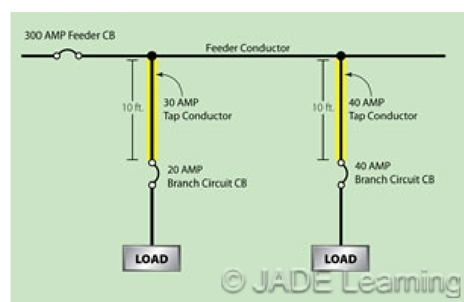
Question 16: A 277/480 volt, 4-wire panelboard supplies a multiwire branch circuit for three, 277 volt lighting circuits. Which of the following statements is true?

A: The overcurrent protection for the lighting circuits must be a 3-pole circuit breaker.
B: The overcurrent protection for the lighting circuits must be 3 individual circuit breakers without handle ties.
C: The overcurrent protection for the lighting circuits must be installed on the same phase.
D: The overcurrent protection for the lighting circuits must be either a 3-pole circuit breaker or three single-pole circuit breakers with identified handle ties.

Question 17: 240.21(B)(1) Feeder Taps. Taps Not Over 10 ft. Long.

Question ID#: 10476.0

A general statement in 240.21 says overcurrent protection must be provided in each ungrounded conductor at the point where the conductor receives its supply. Tap conductors are an exception to this rule in that they are conductors which have overcurrent protection that exceeds the value of the conductor.



Special rules apply to feeder tap conductors. A feeder tap conductor is protected at an ampacity greater than its rating.

A tap conductor cannot be tapped to supply another tap conductor (tap a tap). The overcurrent device at the termination of the tap cannot be larger than the ampacity of the wire. In other words, the next higher standard size fuse cannot be selected.

Because the tap conductors do not have proper overcurrent protection they are a lot more dangerous than branch circuit conductors. The Code is very strict about the length of tap conductors because without proper overcurrent protection the conductor could be damaged. The longer the tap, the bigger the tap conductor must be.

If the tap is 10 ft. or less, the ampacity of the tap conductors must be (a) not less than the combined calculated loads on the circuits supplied by the tap conductors and (b) not less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors or not less than the rating of the overcurrent protective device at the termination of the tap conductors. However, an exception permits tap conductors for specific listed devices like surge suppressors to be sized in accordance with manufacturer's instructions. For field installations, the ampacity of the tap conductors must not be less than 1/10 the rating of the overcurrent device protecting the feeders. For example, if a feeder is protected by a 300-amp circuit breaker, the minimum ampacity of a tap conductor is 30 amps.

These general rules for 10 foot tap conductors make good common sense: (1) the tap conductors will see the combined loads from any equipment which is connected to the taps, so they must be big enough to handle the load. (2) If the tap ends in an overcurrent device which is the beginning of a branch circuit, all of the current on the branch circuit wires will flow on the tap conductors as well.

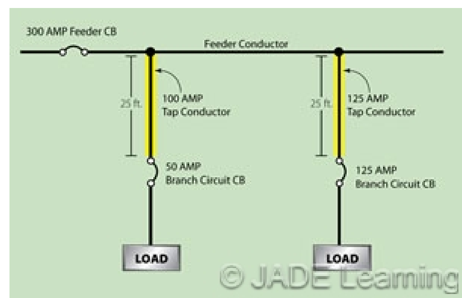
Question 17:   A feeder is protected at 400 amps. An 8 ft. tap is made to the feeder to supply a 40 amp overcurrent protective device which is located outside the enclosure where the tap is made. What is the minimum ampacity of the tap conductor?

A: 30 amps.
B: 40 amps.
C: 100 amps.
D: 400 amps.

Question 18:   240.21(B)(2) Feeder Taps. Taps Not over 25 ft. Long.

Question ID#: 10477.0

As the taps get longer the size of the tap conductor gets larger. For a 10 ft. tap the ampacity of the tap conductor must be at least 1/10 the rating of the feeder overcurrent device. For taps up to 25 ft. the ampacity of the tap conductor must be at least 1/3 the rating of the feeder overcurrent device. More can go wrong on a longer tap, so it must be capable of carrying more current. In addition, a tap up to 25 ft. must be protected from physical damage or enclosed in a raceway and terminate in a single circuit breaker or set of fuses that will limit the load to the ampacity of the tap conductors.
Example No. 1. A 25 ft. tap is connected to a feeder which is protected at 300 amps. The feeder tap terminates at a 50 amp circuit breaker. For any length, the tap is required to be at least 50 amp wire to serve the load, but because it is up to 25 ft. long the ampacity of the tap conductor must be at least 1/3 the rating of the feeder fuse, or 100 amps. (300 amps/3 = 100 amps). See the illustration.



For the same load, a 25 ft. feeder tap must use larger wire than a 10 ft. feeder tap.

Example No. 2. A 25 ft. tap is conected to a feeder which is protected at 150 amps. The feeder tap terminates at a 20 amp fuse. The minimum ampacity of the tap conductor is 50 amps. (150 amps/3 = 50 amps).

Question 18:   A feeder is protected by a 200 amp fuse. A tap conductor is 22 ft. long and terminates in a 40 amp circuit breaker. What is the minimum ampacity of the tap conductor?

A: 40 amps.
B: 63 amps.
C: 67 amps.
D: 200 amps.

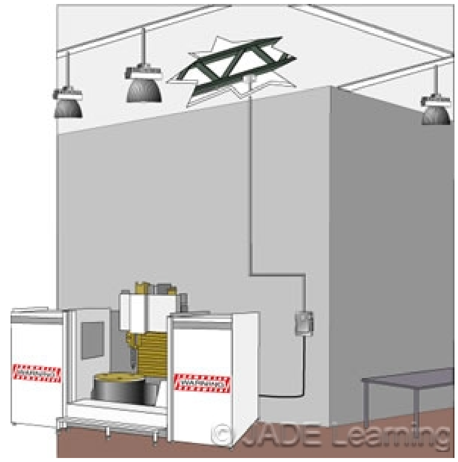
Question 19: 240.21(B)(4)&(5) Feeder Taps. Taps Over 25 ft. Long & Outside Taps.

Question ID#: 10478.0

In high bay manufacturing buildings if a tap is made in the ceiling it is often more than 25 ft. down the wall to the equipment. Taps over 25 ft. long are permitted in high bay manufacturing facilities to allow for longer tap conductor runs.

As usual, though, there are a number of conditions:

- Only qualified people may service the system.
- The tap conductors are not over 25 ft. long horizontally and not over 100 ft. total length.
- The tap conductors must be rated at least 1/3 the ampacity of the feeder OCPD.
- The tap conductors terminate in a single circuit breaker or a single set of fuses.
- The tap conductors are protected from physical damage.
- The tap conductors are continuous from end to end without splices.
- The tap conductors are minimum size 6 AWG copper or 4 AWG aluminum.
- The tap conductors do not penetrate walls, floors or ceilings.
- The tap is made no less than 30 ft. from the floor.



Feeder taps longer than 25 ft., such as in a high bay manufacturing building, are permitted, but must meet many conditions.

Question 19: In a high bay manufacturing building a feeder is tapped in the ceiling 40 ft. from the floor. The tap is in conduit and travels horizontally to the wall for 10 feet and vertically down the wall for 35 ft. How much farther can the conduit be extended horizontally?

A: 15 ft.
B: 35 ft.
C: 40 ft.
D: 50 ft.

Question 20: 240.21(C)(1)(2)&(3) Transformer Secondary Conductors.

Question ID#: 10479.0

Transformer secondary conductors can be installed without overcurrent protection at the transformer if the conditions of 240.21(C) are met.
A 2-wire secondary of a single phase transformer is considered protected by the primary overcurrent protection and does not need protection on the secondary.

Overcurrent protection at the secondary of a transformer can be omitted if the secondary conductors are not longer than 10 feet ***and*** all of the following conditions are met:

- The ampacity of the secondary conductors is not less than:

a. The total load on the secondary conductors.
b. The rating of the device supplied by the secondary conductors or the rating of the overcurrent device supplied by the secondary conductors.

- The secondary conductors do not extend beyond the equipment that they supply.
- The secondary conductors are enclosed by a raceway from the transformer to the equipment they supply.
- Because the primary OCPD provides protection for the secondary transformer conductors, the NEC specifies a minimum ratio between the size of the primary OCPD and the ampacity of the secondary conductors.

Overcurrent protection on the secondary side of a transformer can be omitted if the tap conductor on the secondary side of the transformer meets all the conditions in this section.

For Example:
If OCPD is installed only on the transformer primary, what is the minimum ampacity & size of secondary conductors that are not over 10-ft. long?

Transformer data: 100 KVA, 3-phase, 480-VAC primary: 208 Y/120 secondary

Primary current rating is 100,000 Ã· (480 x 1.73) = 120.42-A
Primary OCPD is 150-A (table 450.3(B), Note1)

Ratio of primary to secondary line to line voltage = 480 Ã· 208 = 2.31

10% of Primary OCPD 150-A = 15-A

15-A x 2.31 = 34.65-A

Minimum ampacity of secondary OCPD = 34.7-A

From table 310.16; Smallest 60Â°C conductor is a #8 AWG copper

In industrial installations where maintenance and supervision ensure that only qualified persons service the systems, if the secondary conductors are 25 ft. or less, overcurrent protection is not required if:

- The ampacity of the secondary conductors is not less than the secondary current rating of the transformer, and the sum of the ratings of the overcurrent devices does not exceed the ampacity of the secondary conductors.
- All overcurrent devices are grouped.
- The secondary conductors are suitably protected from physical damage by being enclosed in an approved raceway or by other approved means.

Question 20: Transformer secondary conductors are not over 10 ft. long and are installed in a raceway without overcurrent protection to a disconnect with 200 amp fuses. The disconnect will supply a 175 amp load. Which of the following is a true statement?

A: The secondary conductors must be rated at least 200 amps.
B: The secondary conductors must be rated at least 175 amps.
C: The installation as described is a Code violation.
D: Transformer secondary conductors must be protected at the transformer.

Question 21: 240.21(C)(4)&(6) Outside Transformer Secondary Conductors and Transformer Secondary Conductors Not Over 25 ft. Long.

Question ID#: 10480.0

The requirements for outdoor transformer taps are not as strict as for transformer taps inside a building.

Outside transformer secondary conductors can be installed in any length if they are protected from physical damage and have an ampacity large enough to feed the load on the secondary conductors, or have a rating equal to or greater than a single overcurrent device at the termination of the secondary conductors. The single overcurrent device must be part of a disconnecting means or right next to one. The disconnecting means for the outside transformer secondary conductors must be readily accessible either outside the building or inside nearest the point of entrance.

Indoor transformer secondary conductors can be installed in lengths up to 25 ft. in most conditions which are standard for commercial work. The conductors must be protected from physical damage and terminate in a single circuit breaker or set of fuses which limit the current to the ampacity of the secondary conductors.

Also, the ampacity of indoor secondary conductors shall be no smaller than the primary to secondary transformer voltage ratio multiplied by 1/3 the rating of the transformer primary overcurrent device. For example, for a transformer with a 480 volt single-phase primary and a 240 volt single-phase secondary, the ratio is 2 to 1. If the transformer primary was protected at 300 amps, 1/3 the rating is 100 amps. Multiply 100 amps by 2 to get 200 amps. The minimum ampacity of the transformer secondary conductors is 200 amps.

Question 21: Which of the following statements is true?

A: Outside transformer secondary conductors are limited to 100 ft. in length.
B: Indoor transformer secondary conductors not over 25 ft. long must terminate in an overcurrent device which limits the load current to the ampacity of the conductors.
C: Indoor transformer secondary conductors not over 25 ft. long cannot be smaller than 1/3 the rating of the transformer primary overcurrent device.
D: Outdoor transformer secondary conductors must terminate in a disconnecting means located outside the building.

Question 22: 240.22 Grounded Conductor.

Question ID#: 10481.0

Overcurrent devices are not permitted to be installed in series with grounded conductors unless (1) the overcurrent device opens all conductors of the circuit, including the grounded conductor, and is designed so that no pole can operate independently, or (2) where required by 430.36 or 430.37 for motor overload protection.

Overcurrent protection is not installed in series with the grounded neutral conductor unless it disconnects the ungrounded conductors as well.

Fusing a grounded conductor is dangerous because if the fuse in the grounded conductor blows, no current will flow in the circuit and the equipment will not operate, but if the ungrounded conductors are still connected to the load they remain energized and pose a serious shock hazard.

Wiring to a gasoline dispensing pump has a similar requirement to disconnect the grounded and ungrounded conductors. All the conductors to the pump must be disconnected at the same time, including the grounded conductor. If the grounded (neutral) and the ungrounded conductors are disconnected from the pump there is no possibility of any current returning through the neutral and causing a spark.

Overcurrent protection can be placed in the grounded conductor when used for motor overload protection (430.36 & 430.37). However, the only time this is allowed is when the supply circuit is a 3-wire, 3-phase system and one of the phase wires is grounded, like in a corner grounded 3-phase delta system.

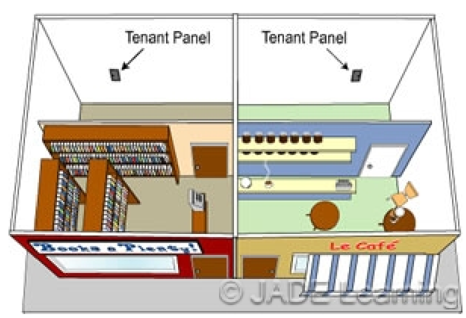
Question 22: Installing an overcurrent device in the grounded conductor:

A: Is permitted if the device opens all conductors of the circuit.
B: Is a common practice for motor overload protection.
C: Is not permitted in service station wiring.
D: Is not allowed under any circumstances.

Question 23: 240.24 Location of Overcurrent Devices on the Premises.

Question ID#: 10482.0

Overcurrent devices must be readily accessible. Readily accessible means capable of being reached quickly for operation. When used as switches the center of the operating handle cannot be mounted higher than 6 ft. 7 inches.



Each building occupant must have access to the overcurrent devices protecting their space.

Overcurrent devices cannot be located in bathrooms in dwelling units, dormitories, and guest rooms or guest suites. Overcurrent devices are also prohibited in clothes closets because lint from clothes is very flammable or in other areas with easily ignitable material. Overcurrent devices cannot be exposed to physical damage.

Each occupant must have access to all overcurrent devices protecting the conductors that supply that tenant space. With the exception of hotels and motels, the branch circuit breakers for each tenant space must be located so the tenant can easily get to them. If electrical maintenance is provided by the building management, the feeder and service overcurrent devices can be accessible only to authorized management personnel. In hotels and motels with electrical maintenance personnel, the branch circuit breakers for each room are not required to be located in the guest room.

Overcurrent devices located next to utilization equipment are permitted to be accessible by ladders or other portable means. A fused disconnect for an air handler located above a suspended ceiling is not readily accessible, but is still acceptable because it serves utilization equipment.

Question 23: Which of the following is a Code violation?

A: A fusible disconnect switch for an air compressor located on a walkway.
B: Circuit breakers in a panelboard located outside a bathroom.
C: Feeder breakers for a tenant space accessible only to building management electrical maintenance personnel.
D: A fusible disconnect switch installed so that the handle is 6 ft. 10 in. above the floor.

Question 24: 240.30 Protection from Physical Damage. 240.33 Mounted in Vertical Position.

Question ID#: 10483.0

Enclosures for overcurrent devices may be mounted in the horizontal position if mounting vertically is impracticable and the on position is the up position of the circuit breaker handle.

Overcurrent devices are protected from physical damage by being installed in enclosures, cabinets, cutout boxes, or equipment assemblies. Enclosures for overcurrent devices are generally mounted in the vertical position, however, enclosures are permitted to be mounted horizontally where vertical mounting is impracticable provided the circuit breakers clearly indicate the ON and OFF position of the breaker's handle. Where circuit breaker handles are operated vertically rather than rotationally or horizontally, the "up" position of the handle shall be the "on" position.

Section 240.33 allows enclosures for overcurrent devices to be mounted in the horizontal position if it is impracticable to mount them in the vertical position. If mounting the enclosure in the horizontal position causes the circuit breaker handles to be operated in the vertical position, the up position of the handle shall be the on position.

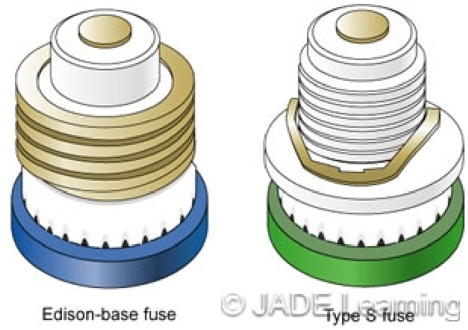
It is not clear what impracticable means. It is not defined in Article 100 or Article 240. The authority having jurisdiction decides whether it was impracticable to mount the enclosure in the vertical position. The vertical space would have to be severely restricted and without other options for mounting the circuit breaker or fuses vertically in order for it to be permitted.

Question 24: Which of the following is a true statement?

A: Circuit breaker enclosures are always required to be mounted in a vertical position.
B: Circuit breaker enclosures may be mounted in the horizontal position if it is not practicable to mount the inclosure in the vertical position and all the circuit breaker handles are up in the on position.
C: Circuit breaker enclosures may never be mounted in the horizontal position.
D: All circuit breaker enclosures are required to be mounted so that the circuit breaker handles operate vertically.

Question 25: 240.50 & 240.54 Plug Fuses, Fuseholders, and Adapters.

Question ID#: 10484.0



Many older homes still use Edison-base or Type S plug fuses.

Plug fuses are the old screw-in type.Â There are two types of plug fuses: Edison-base and Type S.Â The Edison-base fuses have a larger diameter metallic base than the S-type which have a porcelain base.Â Edison-base fuses are dangerous because it is physically possible to replace lower rated fuses that have blown with higher rated fuses.Â Many house fires have been caused by homeowners replacing a blown 15 amp fuse with a 30 amp fuse.Â Edison-base fuses can only be used as replacements in existing installations.Â If additional Edison-base fuseholders are installed they must be fitted with S-Type adapters.

Plug fuses are only permitted on circuits where the voltage between conductors is 125 volts or less.Â They can only be used on systems with a grounded neutral pointÂ and the line-to-neutral voltage does not exceed 150 volts.

The screw shell of a plug-type fuseholder must be connected to the load side of the circuit.

Type S fuses are classified 0-15 amps, 16-20 amps, and 21-30 amps.Â A type S fuse of one classification is not interchangeable with a fuse of a lower classification. Type S fuses have narrow barrels and will only fit in a Type S fuseholder or a fuseholder with a Type S adapter.Â Once a Type S adapter has been installed in a fuseholder it cannot be removed.

Note: The NEC has three different classifications of type S fuses.Â None of the type S classifications will interchange with any of the other classes.

Question 25: Why are Type S fuses safer than Edison-base fuses?

A: The screw shell of the Type S fuseholder is connected to the load side of the circuit.
B: Type S fuses can be used only on line-to-neutral loads.
C: Type S fuses of a higher ampere rating will not fit a Type S holder with a lower ampere classification.
D: Edison-base fuses do not blow at their rated ampacities.

Question 26: Part VI. 240.60(A-C) Cartridge Fuses and Fuseholders.

Question ID#: 10485.0

Fuses are designed to work at different voltage and current levels. A current limiting fuse holder will only accept a current limiting fuse.

There are two basic types of fuses used on circuits which are 600 volts or less:
(1) 300 volt type
(2) 600 volt type
The longer 600 volt fuses will not fit into a 300 volt fuseholder and the 300 volt type will not fit into a 600 volt fuseholder. Fuses are also made with different diameter barrels which get bigger as the ampere rating increases. This is done so a blown fuse cannot be replaced with a fuse of a higher rating. Fuses of any rating must be marked with the ampere and voltage rating, the interrupting rating (AIC) if it is other than 10,000 amps, whether or not it is current limiting, and the name or trademark of the manufacturer.

The 300 volt type fuse can be used on circuits where the voltage between conductors is not more than 300 volts, or on single-phase line-to-neutral loads from a 3-phase, 4-wire wye system where the line-to-neutral voltage is not greater than 300 volts.

Current-limiting fuses are fast acting fuses which can clear a fault in less than half a cycle. Equipment downstream from the current-limiting fuse can have interrupting ratings which are equal to the let-through current of the current-limiting fuse. These downstream reduced interrupting ratings are usually less than the available fault current. Equipment with lower interrupting ratings is much less expensive than equipment with higher interrupting ratings.

If a current-limiting fuse must be replaced it is very important it is not replaced with a non-current limiting fuse. Fuseholders for current-limiting fuses are made with rejection features which prevent a non-current-limiting fuse from being installed. The rejection feature is usually a bar across the clips of the fuseholder or a slot in the clip which will accept a grooved ring on the ferrule of a current-limiting fuse.

Question 26: Which of the following statements is true?

A: A current-limiting fuse will not fit into a non-current-limiting fuseholder.
B: A current-limiting fuseholder will reject a non-current-limiting fuse.
C: A 300-volt type fuse cannot be used on a 277 volt single-phase circuit.
D: A 600-volt type fuse could fit into a 300-volt type fuseholder.

Question 27: 240.80 -- 240.83 Circuit Breakers.

Question ID#: 10486.0

These sections discuss some well known facts about circuit breakers:

- They must clearly indicate whether they are in the on or off position.
- The on position must be up; the off position must be down, with the exception of 240.33 (when mounted horizontally).
- The trip setting and time delay features must be tamperproof.
- The voltage and current rating must be clearly marked.
- If the interrupting rating (AIC) is other than 5000 amps it must be marked.
- They shall be trip free and capable of being opened and closed manually.

This Code section contains rules for circuit breaker manufacturers and circuit breaker installers.

In addition to the above general requirements, circuit breakers that are used as switches for some types of lighting circuits require special markings.

Because of the electrical characteristics of HID lights, circuit breakers used as switches for circuits that supply HID lights have to be able to withstand significant arcing that occurs each time the circuits are opened. Breakers used as switches for HID lighting circuits are required to be marked HID. The most common types of HID (High Intensity Discharge) lighting are listed below:

- Mercury-vapor lamps
- Metal-halide (MH) lamps
- Ceramic MH lamps
- Sodium-vapor lamps
- Xenon short-arc lamps

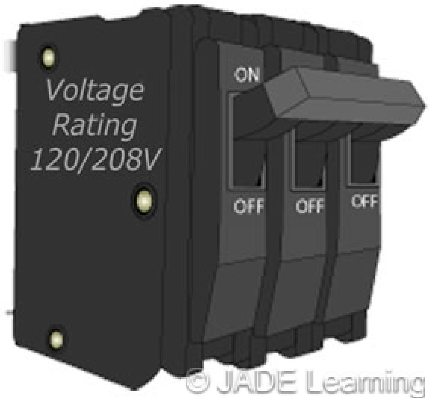
Note: Fluorescent lights are ***NOT*** HID lights. Circuit breakers used as switches for fluorescent lights are ***NOT required to be marked HID***. A circuit breaker that is marked HID is permitted used to control any load that an SWD circuit breaker can. However, a breaker that is marked SWD cannot be used to control a HID load. This means that breakers used as switches for fluorescent light circuits are required to be marked either SWD or HID.
Note: SWD--switching duty HID--high intensity discharge

Question 27: When circuit breakers are used as switches:

A: They must be listed and marked with both SWD and HID if used on fluorescent lighting circuits.
B: They must be listed and marked SWD if used on high intensity discharge lighting circuits.
C: They must be listed and marked either SWD or HID if used on 120 VAC or 277 VAC fluorescent lighting circuits.
D: They must be listed and marked HID if used on fluorescent or high intensity discharge lighting circuits.

Question 28: 240.85 Applications of Circuit Breakers.

Question ID#: 10487.0



The voltage to ground on a circuit breaker with a slash rating cannot be more than the lower rating on the breaker.

If a circuit breaker has a straight voltage rating, such as 240 volts, it can be used in an AC system where the voltage between any two conductors is not greater than the single voltage rating of the circuit breaker. If a circuit breaker has a slash rating, like 120/240 volts, it can be used in an AC system where the voltage between phase conductors is not greater than the higher rating (240 volts), and the voltage to ground is not greater than the lower rating (120 volts).

A circuit breaker with a 120/240 rating could be used on a 3-phase, 4-wire 120/208 volt system because the phase-to-phase voltage is less than 240 volts and the phase-to-ground voltage is 120 volts. A breaker with a 120/240 volt rating could not be used on a 277/480 volt system because both the system phase-to-phase and the phase-to-ground voltage are greater than the rating of the breaker.

In a 3-phase, 3 wire, corner grounded delta system, one of the phase legs is grounded. If the system voltage was 480 volts then the single-phase voltage between any one ungrounded conductor and the grounded leg would be 480 volts. A circuit breaker with a 277/480 volt rating could not be used on such a system because the voltage to ground is greater than 277 volts.

Question 28: A single-pole breaker is used on a 277/480 volt, 3-phase, 4-wire system. Which of the following ratings on the breaker could be used?

A: 120/240 volts.
B: 240 volts.
C: 277/480 volts.
D: 120/208 volts.

Question 29: 240.86 Series Rating.

Question ID#: 10488.0

A series rated system of feeder and branch circuit breakers refers to an arrangement where the branch circuit breakers are permitted to be used in locations where the available fault current is above their interrupting rating. A series rated system is a way to avoid having to pay for a fully rated system, where every circuit breaker has an interrupting rating equal to or greater than the available fault current. Circuit breakers above the standard 10,000 amps interrupting rating can get very expensive.

Series rated overcurrent protective systems are permitted, but must be labeled. Identical replacement parts are required.

In a series rated system, the feeder and branch circuit breakers have been tested in combination and have been proven to work together to prevent the branch circuit breaker from exploding, even when a short circuit occurs on the load side of the branch circuit breaker and the fault current is greater than the branch circuit breaker's interrupting rating.

For example, in a series rated system, a feeder breaker has an interrupting rating of 22,000 amps and a branch circuit breaker has an interrupting rating of 10,000 amps. If a fault occurs downstream from the branch circuit breaker, the fault current can climb above its interrupting rating, but at a point between 10,000 amps and 22,000 amps the feeder breaker will trip and de-energize the circuit before the branch circuit breaker is damaged. The resistance of the arcs from the feeder breaker and the branch circuit breaker are in series with each other, and the high resistance of the arc reduces the fault current that the branch circuit breakers actually see.

Under fault conditions, in a series rated system the feeder and branch circuit breakers work together to reduce the fault current on the downstream breaker. The disadvantage is that because the feeder breaker trips, more of the system is taken offline.

The overcurrent devices must be labeled to identify them as being part of a series rated system. Only unique combinations of circuit breakers can be part of a series rated system. If a non-series rated breaker is used to replace a component of a series rated system, it may not work in the proper way and put the whole system in danger.

Question 29: Which of the following best describes a series rated system?

A: The feeder and branch circuit breakers are fully rated for the available fault current.
B: The interrupting rating of the branch circuit breaker is not important.
C: The feeder breaker protects the branch circuit breaker.
D: The feeder breaker and the branch circuit breaker work together to reduce the fault current seen by the branch circuit breaker.

Question 30: 240.90 & 240.2 Supervised Industrial Locations.

Question ID#: 10489.0

A supervised industrial location is defined in 240.2 as the manufacturing part of a facility that meets 3 conditions:

- ***Conditions of maintenance and engineering supervision ensure that only qualified persons monitor and service the system.***
- ***The premises wiring system has 2500 kVA or greater of load used in industrial process(es), manufacturing activities, or both, as calculated in accordance with Article 220.***
- ***The premises has at least one service or feeder that is more than 150 volts to ground and more than 300 volts phase-to-phase.***

In supervised industrial locations, certain procedures for protecting conductors and equipment are permitted which would not be allowed in other occupancy types.

The definition of Supervised Industrial Installation, in section 240.2, does not include those parts of the property that are used for ***"offices, warehouses, garages, machine shops, and recreational facilities."***

Supervised industrial locations are given special treatment because of the high level of engineering and professional maintenance support which is usually available in these facilities. The Code assumes that people doing electrical work in industrial facilities are ***qualified*** according to the definition in Article 100, which says a ***qualified person*** is one ***who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training on the hazards involved***. Not only are the electricians qualified, but they are supervised by competent professionals.

At least one of the other two conditions limit the definition of a supervised industrial installation to large manufacturing or process control plants. A 2500 kVA load calculated according to Article 220 would be over 3000 amps, assuming most of the equipment was operated at 480 volts, 3-phase (2,500,000 VA /480 x 1.73 = 3012 amps). This load excludes any part of the installation that is not manufacturing, like offices, warehouses, garages, machine shops, and recreational facilities.

Question 30: Which of the following installations would qualify as a supervised industrial installation?

A: A 2500 sq. ft. bakery with 1500 kVA of load.
B: A large mall with 3000 kVA of load.
C: A tire plant with 4000 kVA of load.
D: A multi-tenant building with professional property management personnel responsible for maintenance on the property.

Question 31: 240.92 Overcurrent Protection in Industrial Locations.

Question ID#: 10490.0

This section loosens the requirements for transformer secondary taps and outside feeder taps in supervised industrial locations. The rules can be relaxed because of the engineering and professional maintenance support at these facilities.

Section 240.92(B) and table 240.92(B) permit tap conductor short-circuit current ratings to be calculated under engineering supervision. The calculated values done in accordance with table 240.92(B) may be less than are required elsewhere in the NEC.

Transformer secondary conductors shall be protected from short-circuit and ground-fault conditions if they meet the conditions of this section. However, if the ampacity of the secondary conductors is calculated under engineering supervision, the transformer secondary taps are considered protected against short-circuits, ground-faults and overloads for any distance without other conditions.

Outside feeder taps may be tapped to a feeder or connected to a transformer secondary without overcurrent protection at the tap if the sum of the overcurrent devices at the conductor termination limits the load to the conductor ampacity and there are not more than 6 overcurrent devices grouped in one location.

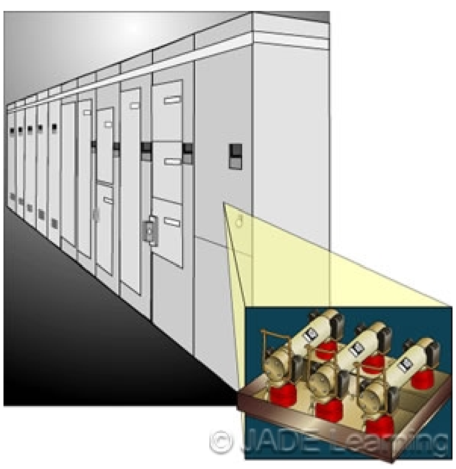
Engineers in supervised industrial locations are permitted to calculate the rating of transformer taps and outside feeder taps.

Question 31: Which of the following statements is true?

A: The requirements for supervised industrial locations are the same as for any other location.
B: An outside feeder tap rated at 350 amps can be protected by two 200-amp fusible disconnects at the termination of the tap.
C: In supervised industrial locations, all transformer secondary conductors must be protected at the transformer.
D: In supervised industrial locations, transformer secondary taps can be calculated under engineering supervision.

Question 32: 240.100 & 240.101 Overcurrent Protection over 1000 Volts, Nominal.

Question ID#: 10491.0



The required rating of overcurrent protection in circuits over 1000 volts is larger than the required rating in circuits 1000 volts and below.

Like in supervised industrial locations, circuits over 1000 volts in any location can be protected at locations other than at the point of supply if there is engineering supervision.

In circuits over 1000 volts, Section 240.101 requires that the rating of the fuse cannot be more than 3 times the ampacity of the conductors. The long-time trip setting of a breaker cannot be more than 6 times the ampacity of the conductor.

This is a good example of how different over 1000 volt installations are from 1000 volt and below installations. For 1000 volts and below, overcurrent protection for a conductor cannot be more than the next standard size fuse or breaker. In over 1000 volt installations, a fuse can be 3 times the rating of the conductor and a breaker can be 6 times the rating of the conductor.

Question 32: A 2300 volt, 200 amp feeder, is protected by a non-time delay fuse. The rating of the fuse cannot be more than:

A: 200 amps.
B: 600 amps.
C: 800 amps.
D: 2300 amps.

Question 33: 408.30 & 408.36 Overcurrent Protection for Panelboards.

Question ID#: 10492.0

Panelboards are required to have a capacity no less than the feeder capacity supplying the panelboard as calculated under Article 220.

Panelboards are required to be protected by an Overcurrent Protective Device that has a rating not greater than the rating of the panelboard. The Overcurrent Protective Device can be a Main that is installed in the panelboard, or the Main can be located outside the panelboard, such as when a fusible disconnect supplies a main lugs only panelboard.

There is no longer a distinction between a Lighting and Appliance panelboard and a Power panelboard. Individual panelboards can be manufactured to hold more than 42 circuit breakers.

Overcurrent protection for panelboards protects the panelboard busbars and the panelboard lugs where the feeder conductors terminate. The overcurrent protection in the panelboard protects the panelboard, not the panelboard feeder or branch circuits and feeders that are supplied by the panelboard.

The rating of OC protection for a panelboard cannot be greater than the rating of the panelboard busbars.

Question 33: A feeder fuse rated at 400 amps supplies a main lugs only panelboard. The calculated load on the panelboard is 350 amps. The feeder is 500 kcmil, rated at 380 amps. What is the minimum rating of the panelboard?

A: 350 amps.
B: 380 amps.
C: 400 amps.
D: 600 amps.

Question 34: 408.36(A)(B)(C)(D) Overcurrent Protection for Panelboards.

Question ID#: 10493.0

The overcurrent protection for a panelboard that is supplied from a transformer on the secondary side of a transformer must protect the panelboard busbars and the transformer secondary conductors.

(A) Snap Switches Rated at 30 Amperes or Less. Panelboards that have snap switches rated at 30 amps and less must have overcurrent protection rated at 200 amps or less.

(B) Supplied Through a Transformer. Most panelboards that are supplied by a transformer must have the panelboard overcurrent protection located on the secondary of the transformer. However, an exception to 408.36 permits transformer primary overcurrent protection of some single-phase transformers with a 2-wire (single voltage) secondary and some 3-phase, delta-delta connected transfomers with a 3-wire (single-voltage) secondary to protect the panelboard.

(C) Delta Breakers. A three-phase circuit breaker cannot be connected to any panelboard that has less than three phases.

(D) Back-Fed Devices. Plug-in type circuit breakers that are back-fed must be secured in place by an extra fastener that requires more than a pulling motion to release the circuit breaker.

Question 34: Which of the following statements about overcurrent protection for panelboards is true?

A: All circuit breakers in 3-phase panelboards must have a dual voltage rating.
B: Plug-in circuit breakers that are used to energize a panelboard bus must be secured in place so that they may not be pulled out by hand.
C: Panelboards that are supplied through a transformer must have overcurrent protection for the panelboard located outside the panelboard.
D: A panelboard with 10% or more of the circuit breakers rated 30 amps or less is a lighting and appliance type panelboard.

Question 35: 422.11 Overcurrent Protection for Appliances.

Question ID#: 10494.0

If an appliance manufacturer marks an appliance with a maximum overcurrent protection size, then the branch circuit fuse or breaker cannot be larger than what is marked on the appliance. This is an example of the general statement in 110.3(B) which states: ***Listed or labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling***. The Code recognizes that the manufacturer knows his product better than anyone else and if he wants a certain size fuse or breaker to protect the appliance then that is what should be installed.

The overcurrent protection for an appliance cannot be greater than what the manufacturer requires.

There are requirements in this section to subdivide appliance loads once they exceed certain sizes. For example, electric heating appliances must subdivide loads larger than 48 amps into loads not larger than 48 amps, and protect each subdivided load by not more than 60 amps, see 422.11(F).

Subdividing loads is another way of protecting the equipment. A 100 amp electric heating appliance will be better protected by two 50 amp breakers than one 100 amp breaker because the faulted heating element will be taken offline quicker. Problems on 50 amp circuits are not as bad as problems on 100 amp circuits.

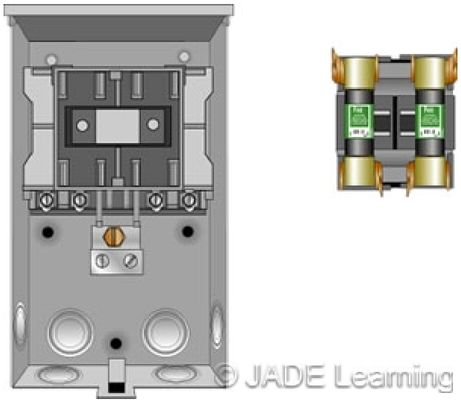
Other appliances like infrared lamp commercial and industrial heating appliances, household-type appliances with surface heating elements and commercial kitchen and cooking appliances are discussed here with specific overcurrent requirements.

Question 35: An electrical contractor installed a 60 amp conductors and 60 amp circuit breaker as shown on the prints for a food warmer in a commercial kitchen.Â When the appliance arrived it was markedÂ "maximum overcurrent protectionÂ 50 amps."Â What should the electrical contractor recommend?

A: Remove the 60 amp breaker in the panelboard and install a 50 amp breaker.
B: Leave the 60 wire and 60 overcurrent protection in place.
C: Install new 40 amp wire and a 50 amp circuit breaker.
D: Tell the owner to return the 50 amp food warmer to the manufacturer.

Question 36: 424.3(B) and 424.22(B) Fixed Electric Space-Heating Equipment Overcurrent Protection.

Question ID#: 10495.0



Fuses used to protect fixed electric space-heating equipment must be sized at no less than 125% of the total load on the equipment.

The NEC considers fixed electric space heating equipment a continuous load according to 424.3(B). Branch circuit overcurrent protection for fixed electric space-heating equipment must be sized at no less than 125% of the combined load on the resistance elements and any motors.

Loads larger than 48 amps must be subdivided and protected at not more than 60 amps. Each of the subdivided loads must have supplementary overcurrent protection in addition to the branch circuit fuse or breaker. The supplementary overcurrent protection must also be sized at no less than 125% of the load, but it is provided by the equipment manufacturer.

Question 36: The load on a fixed electric space heater is 40 amps. What is the minimum size overcurrent protection required?

A: 40 amps.
B: 50 amps.
C: 60 amps.
D: 80 amps.

Question 37: 430.52 Branch-Circuit and Short-Circuit Protection for a Single Motor.

Question ID#: 10496.0

Branch-circuit and short-circuit protection for a single motor is selected from Table 430.52, based on the full load current of the motor.

Motors are protected against 2 hazards: (1) short-circuits and ground-faults and (2) overloads.

Overload protection de-energizes the control circuit to the motor through the overload relays or heaters in the motor starter. Motors get overloaded when bearings wear out or process machinery get jammed. Overload protection is completely separate from branch-circuit short-circuit and ground-fault protection and is described in part III beginning with section 430.31 where a FPN refers to article 100 for the definition of ***Overload***.

Overload. "Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload."

The branch circuit fuse or circuit breaker protects the motor and motor conductors from short-circuits and ground-faults. Table 430.52 is used to size the overcurrent device based on a percentage of motor full load current. Motor full load current for single phase AC motors is found in Table 430.248 and for 3-phase AC motors in Table 430.250.

Examples of sizing single motor branch-circuit and ground-fault protection:

Example 1:
2 hp 208 V. single phase AC motor: From Table 430.248, Full Load Amps = 13.2 amps.
From Table 430.52: time delay fuses single phase AC = 175% of full load amps

Calculation: 13.2 amps x 175% = 23.1 amps
Use the next highest standard fuse from 240.6A = 25 amp time delay fuse

Example 2:
10 hp, 230 V. 3-phase motor. From Table 430.250, FLA = 28 amps
From Table 430.52 for an Inverse Time breaker = 250% of FLA
Calculation: 28 amps x 250% = 70 amps. Use a 70 amp breaker

Question 37: What are the correct size time delay fuses for a 15 hp, 460 volt, 3-phase AC, squirrel-cage induction motor that has a Full Load Current (FLC) rating of 21 amps?

A: 35 amps.
B: 40 amps.
C: 50 amps.
D: 60 amps.

Question 38: 430.52(C)(1) Ex. 2 When the Motor Will Not Start.

Question ID#: 10497.0

If a motor will not start, higher values of overcurrent protection can be selected.

Section 430.52 (C)(1) Exception No. 2 allows the percentages in Table 430.52, which are used to size the branch-circuit and ground-fault protective devices, to be increased if the motor will not start.

There are thousands of different applications for electric motors. Motors drive fans, pumps, conveyors, compressors, tools and all types of machinery. The length of time it takes the motor to start depends on the type of load it is driving. If a motor must start under load the fuse might blow or the breaker might trip before the motor gets the load moving.

There is no way to predict how every motor will be used and what the safest size overcurrent device is to both protect the circuit and allow the motor to start. So Exception No. 2 allows the installer to increase the size of the device if the original fuse or breaker will not allow the motor to start.

According to Exception No. 2, if a motor will not start, the overcurrent device can be increased but cannot be larger than the Full Load Amps of the motor times the maximum setting of the overcurrent device as specified in exception #2. This means if the rating of the overcurrent device is between 2 standard sizes, the next lower size must be chosen.

OCPD ratings as a % of FLA for single phase & 3-Phase Motors

Overcurrent Device	***Normal Setting***	***Maximum Setting***
Non-time Delay Fuse	300% of FLA	400% of FLA

Dual Element Time Delay Fuse

175% of FLA

225% of FLA

Inverse Time Breaker 100-A or less

250% of FLA

400% of FLA

Inverse Time Breaker or more than 100-A

250% of FLA

300% of FLA

Example #1:
A 25 hp, 3-phase 460 volt AC motor that draws 34 FLA will not start under load. What is the maximum size time delay fuse?
Calculation: 34 amps x 225% = 76.5 amps. Select the next ***lower*** standard size fuse = 70 amps

Example #2:
A 15 hp, 3-phase 230 volt AC motor that draws 42 FLA will not start under load. What is the maximum size inverse time circuit breaker?
Calculation: 42 amps x 400% = 168 amps. Select the next ***lower*** standard size inverse time circuit breaker = 150 amps

Question 38: A 50 hp, 3-phase, 460 volt AC motor that draws 65 amps will not start under load. What is the maximum size time delay fuse?

A: 175 amps.
B: 150 amps.
C: 125 amps.
D: 110 amps.

Question 39: 430.62 Motor Feeder Short-Circuit and Ground-Fault Protection.

Question ID#: 10498.0

A motor feeder that supplies more than a single motor is protected according to the requirements in Code section 430.62.

Motor feeders supply multiple motors and the motor feeder fuse or breaker must protect the motor feeder conductors. The motor feeder overcurrent protective device is sized in 3 steps:

- Take the actual size of the largest branch circuit overcurrent device
- Take the FLC of all other motors on the feeder at 100%
- Select the next lower size standard fuse if the calculated value does not match a standard size

Example #1
A feeder supplies three 10 hp, 230 volt, 3-phase AC motors. The feeder and all the branch circuit devices are time delay fuses. The Full Load Current for a 10 hp, 3-phase, 230 volt AC motor is 28 amps (determined from table 430.250). 28 A X 175% (175% from table 430.52) = 49 amps. Branch circuit fuses are rounded up to 50 amps.

Feeder OCPD
Calculation example #1: 50 amps + 28 amps + 28 amps = 106 amps.
For the OCPD protecting the feeder, select the next lower standard size fuse = 100 amps.

Example #2
A feeder supplies two motors; the feeder and branch circuit OCPDs are time delay fuses:
Motor #1 is a 10-HP, 460-V, 3-phase AC motor. (FLC is 14 amps).

14 A X 175% = 24.5 A. Branch circuit time delay fuses are rounded up to 25 amps.
Motor #2 is a 15-HP, 460-V, 3-phase AC motor. The Full Load Current for a 15 hp, 3-phase, 460-volt AC motor is 21 amps. 21 X 175% = 36.75 A. Branch circuit fuses are rounded up to 40 amps.

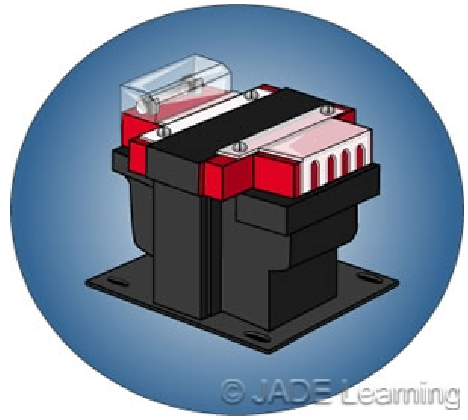
Feeder OCPD
Calculation example #2: Feeder OCPD not larger than the largest branch circuit OCPD + FLC of other motor. Feeder OCPD = 40 amps + 14 amps = 54 amps. For the OCPD protecting the feeder, select the next lower standard size TD fuse = 50-A

Question 39: A feeder supplies three, 15 hp, 208 volt, 3-phase AC motors. The feeder and all the branch circuit devices are protected by time delay fuses. The Full Load Current (FLC) for a 15 hp, 3-phase 208 volt AC motor is 46.2 amps. The branch circuits are protected by 90 amp time delay fuses. What is the maximum size feeder fuse?

A: 90 amp.
B: 200 amp.
C: 150 amp.
D: 175 amp.

Question 40: 430.72 Overcurrent Protection of Motor Control Circuits.

Question ID#: 10499.0



A motor control circuit transformer must have overcurrent protection.

Motor control circuits can be powered in 3 different ways: (1) They can be tapped from the motor branch circuit, in which case the motor control devices, like pushbuttons and limit switches, operate at the same voltage as the motor. (2) They can be supplied by a motor control transformer,with the primary of the control transformer being tapped from the load side of the motor's branch circuit overcurrent protective device. (3) They can be supplied from a source which is completely separate from the motor branch circuit, usually a power supply or directly from a circuit breaker.

Which method is used usually depends on the size of the installation and how it is configured. If the motor starters and branch circuit overcurrent devices are in motor control centers, often motor control transformers are used. If motor control panels are installed usually a power supply is installed. Motor control circuits which are directly tapped to the motor branch circuit conductors are not as common as the other 2 methods because of the higher voltages present on motor control devices.

Table 430.72(B) displays the maximum rating of overcurrent devices which protect motor control conductors. This table covers situations where the motor control conductors are tapped to the motor branch circuit conductors. It lists the maximum setting of overcurrent devices if separate protection is provided for the motor control conductors or if only the motor branch circuit fuses or breakers protect the conductors.

If a control circuit transformer with a primary rating of less than 2 amps is installed to feed a motor control circuit it must be separately protected by an overcurrent device with a rating not more than 500% of the rated primary current of the transformer.

Question 40: Which fuse size would properly protect a control transformer with a primary rating of 1.5 amps when the fuse is installed on the primary of the transformer?

A: 8 amps.
B: 9 amps.
C: 7 amps.
D: 10 amps.

Question 41: 440.22 Motor Compressor Branch-Circuit Short-Circuit and Ground-Fault Protection.

Question ID#: 10500.0

Overcurrent protection for a motor compressor must be selected according to the manufacturer's instructions or the rules of this section, whichever is smaller.

Branch circuit short-circuit and ground-fault protection for motor compressors is similar to overcurrent protection for motor branch circuits as found in Article 430.

In section 440.22(C) it says if there is a conflict between the size of the branch circuit protective device as calculated by Code rules and the size of the device specified by the manufacturer, and the manufacturer's size is smaller, then the manufacturer's size must be used. This is another example of the Code requiring electrical installations to follow the manufacturer's instructions, believing no one knows the equipment like the company that built it.

The branch circuit (fuse or breaker) can be rated at not more than 175% of the compressor full load current. What this means is, if 175% does not correspond to a standard size you need to round down to the next lower standard size found in code section 240.6(A). If the next lower setting will not allow the compressor to start then you can increase the overcurrent protection size to a maximum of 225% of the compressor's FLA.

Whichever percentage is applied, the next lower standard size device must be used because it must have a rating ***not exceeding*** 175% or 225%.

Example 1:
A motor compressor draws 18 amps. 18 amps x 175% = 31.5 amps. Select the next lowest standard size fuse = 30 amps.

Example 2:
A 45 amp circuit breaker installed to protect a motor compressor rated at 26 amps keeps tripping. The circuit breaker size may be increased to 50 amps. 26 x 225% = 58.5 amps. Select the next lower standard size breaker.

Question 41:   An air-conditioning motor compressor has a rated Full Load Current (FLC) of 31 amps. What size fuse should be installed?

A: 35 amps.
B: 40 amps.
C: 50 amps.
D: 60 amps.

Question 42:   450.3(A) Overcurrent Protection for Transformers Over 1000 Volts.

Question ID#: 10501.0

Overcurrent protection for transformers with primaries or secondaries rated over 1000 volts is selected from Table 450.3(A).

Table 450.3(A) lists the maximum overcurrent protection size for transformers over 1000 volts. Transformers are listed according to their impedance and whether or not they are located in a supervised location.

For transformers in supervised locations if the primary is fused at 250% or protected with a breaker not more than 300%, then secondary protection is not required. If fuses or breakers with higher ratings are used on the primary, then secondary protection is required.

The notes to the table are important. Note 1 says the next higher standard size overcurrent device may be used. If Note 1 is not mentioned in the table then the next lower standard size fuse or breaker must be selected. Note 5 says a transformer with coordinated thermal overload protection installed by the manufacturer can omit secondary overcurrent protection.

Question 42:   A transformer in a supervised location with a rated impedance of 8% has an over 1000 volt primary and under 1000 volt secondary. When secondary overcurrent protection is required, what is the maximum percentage of the rated secondary current for a fuse or circuit breaker?

A: 125%
B: 250%
C: 300%
D: 400%

Question 43: Table 450.3(B) Overcurrent Protection for Transformers 1000 Volts or less.

Question ID#: 10502.0

Table 450.3(B) lists the required overcurrent protection for transformers with both primary and secondary voltages 1000 volts or less.

For transformers with primary and secondary currents of 9 amps or more with overcurrent protection on the primary and secondary of the transformer, the primary is protected at 250% of the rated current and the secondary is protected at 125% of the rated current.

On the secondary of the transformer, Note 1 allows the fuse or breaker to be selected from the next higher standard size. On the primary of the transformer the overcurrent protection must be selected from the next smaller standard size.

Example No. 1
A 75 kVA transformer with a 208 volt, 3-phase secondary has a rated secondary current of 208 amps. The maximum size overcurrent protection is 300 amps. 208 amps x 125% = 260 amps. Go up to the next standard size.

Example No. 2
A 50 kVA transformer with a 480 volt, single phase primary has a rated current of 104 amps. The maximum size overcurrent protection is 250 amps. 104 amps x 250% = 260 amps. Go down to the next smaller standard size.

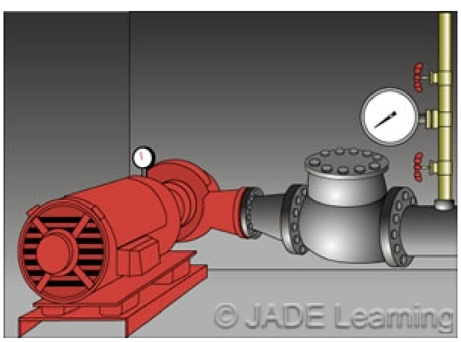
Overcurrent protection for transformers rated 1000 volts or less is selected based on the current rating of the transformer and whether or not OC protection is provided on the primary of the transformer.

Question 43: If a transformer operates at 1000 volts or less, what is the maximum overcurrent protection permitted for the secondary of a 100 kVA transformer with a rated secondary current of 278 amps?

A: 250 amps.
B: 300 amps.
C: 350 amps.
D: 400 amps.

Question 44: 695.4 Continuity of Power for Fire Pumps.

Question ID#: 10503.0



Overcurrent protection for fire pumps is sized based on the locked-rotor current, not full-load current rating.

A fire pump supplies water to the sprinkler system. If the fire pump does not work then the sprinklers do not work and there is no water to suppress a fire. It is much better for the fire pump to burn up than the building.

When a disconnect and overcurrent devices are used, (1) the disconnect must be suitable for use as service equipment, (2) the disconnect must be lockable in the closed position, and (3) the disconnect must be separate from other building disconnecting means and labeled as "Fire Pump Disconnecting Means" so that no one disconnects the fire pump by mistake.

The overcurrent protection is selected to carry the locked rotor current of the fire pump motor and any auxiliary equipment like jockey pumps. In other words, the overcurrent protection would not de-energize the fire pump circuit even if the pump was completely locked-up.

Overcurrent protection for fire pumps is different than other types of protection. There is no overload protection for the fire pump if overcurrent devices are sized to continuously carry locked rotor current.

Question 44: A fusible disconnecting means is installed for a fire pump. Which of the following statements is true?

A: The fuses are sized to carry 175% of the motor full load current.
B: The disconnect may be grouped with other motor disconnects.
C: The fuses protect the fire pump from overloads.
D: Fuses are not used to protect the fire pump from overloads.

Question 45: 230.90 Overcurrent Protection of Ungrounded Service Conductors.

Question ID#: 10504.0

An overcurrent device must be placed in series with each ungrounded service conductor. An overcurrent device may be placed in series with a grounded conductor only if the circuit breaker simultaneously opens all conductors of the circuit.

Each ungrounded service conductor must have overcurrent protection, based on the calculated load of the building.

Five exceptions modify the general statement in 230.90 that the rating of the service overcurrent device cannot be greater than the ampacity of the service conductors.

Exception No. 1 refers to motor loads and says that part of the service load which consists of motor loads should be calculated according to Article 430.

Exception No. 2 says service overcurrent protection may follow 240.4(B) or (C), which allows the next higher standard setting of overcurrent devices, if the service is rated up to 800 amps.

Exception No. 3 says two to six sets of circuit breakers or fuses may be used to provide overload protection. The sum of the ratings of the circuit breakers or fuses can be larger than the ampacity of the service conductors, as long as the service conductors are large enough to carry the load.

Exception No. 4 refers to overcurrent protection for fire pumps.

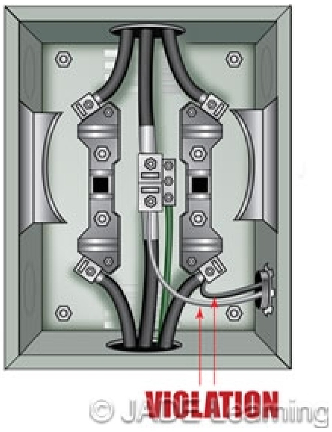
Exception No. 5 allows service overcurrent protection for 120/240-volt, 3-wire, single-phase dwelling services to be selected in accordance with 310.15(B)(7).

Question 45: Which of the following is a Code violation? All equipment is rated for use as service equipment.

A: 400 amp fuses in the ungrounded conductors used to protect a calculated service load of 360 amps.
B: A 600 amp main breaker protecting conductors rated for 590 amps serving a calculated load of 500 amps.
C: 1200 amp fuses, protecting a calculated load of 975 amps, with wire rated for 1140 amps.
D: A 200-amp panel with a 200 amp main breaker protecting a calculated load of 170 amps.

Question 46: 230.94 Relative Location of the Service Overcurrent Device and Other Service Equipment.

Question ID#: 10505.0



With 6 exceptions, equipment cannot be connected on the line side of the service disconnecting means.

The service overcurrent device(s) must protect all circuits and devices. With six exceptions, nothing else can be connected ahead of the service overcurrent devices.

The following devices may be connected on the supply side of the service overcurrent devices: (1) The service switch, (2) Instrument transformers and Type 1 surge-protective devices, (3) Load management devices, (4) Fire alarm, fire pump or other protective signaling systems, (5) Meters in metal housings, properly grounded and not over 600 volts, (6) The control circuit for shunt-trip breakers or other power operated service equipment.

A common Code violation is to connect equipment ahead of the service overcurrent devices. Unlicensed, unqualified people sometimes try to add a circuit ahead of the main breaker if there is no room left in the existing service panel. This violates a number of rules, including: (1) Breaking the seal on a utility meter, (2) Possibly overloading the service conductors, (3) Possibly running unprotected service wires inside a building with no disconnecting means, (4) Violating the 1 wire per terminal rule, (5) Improper grounding, and a number of other important Code requirements.

Question 46: Which of the following statements is true?

A: Nothing can be connected ahead of the service overcurrent devices.
B: Devices without their own internal fuses or breakers can be connected ahead of the service overcurrent protection.
C: Equipment can be connected on the supply side of the service overcurrent devices if the added load does not overload the service conductors.
D: Fire pump feeders may be connected on the supply side of the service.

Question 47: 210.8 Ground-Fault Circuit-Interrupter Protection for Personnel.

Question ID#: 10506.0

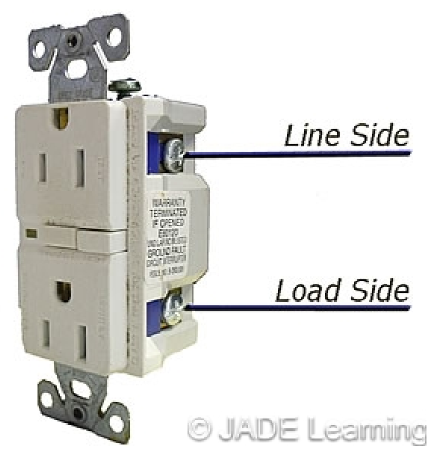
GFCI receptacles will not work if they are wired backwards. Older style GFCI receptacles will still work if the line-load connections are reversed, they just won't provide GFCI protection. The current generation of GFCI receptacles will not work at all, so it will be obvious that something is wrong.

The GFCI's that are commonly used to protect personnel are called Class A GFCI. The definition of Ground Fault Interrupters in article 100 includes a FPN explaining that Class A GFCIs are designed to trip when there is a current imbalance of 6 mA or higher between the circuit conductors that receive power thru the GFCI. The information in the FPN is from ***UL 943, Standard for Ground-Fault Circuit Interrupters.***

The electronics in the current generation of GFCI's is less vulnerable to being damaged by voltage surges and more immune to electrical noise. Their printed circuit boards also have a coating that makes them more resistance to moisture and corrosion.

GFCI receptacles now have a light which is normally off. If the light is on it indicates a problem and the receptacle will not work. The light will come on if the test button is pressed, if there is a ground-fault on the system, if the line-load connections have been reversed or if the GFCI receptacle has been damaged.

GFCI protection, especially in dwellings, has made a tremendous difference in the number of people receiving shocks from defective wiring and in some cases faulty appliances. The number of electrocutions in the home has dropped dramatically since GFCI protection was introduced in the early 70's. The extra money for GFCI



Ground-fault circuit-interrupter receptacles must be wired correctly or they will not work.

receptacles should be well worth it to the customer, since it adds a high level of protection for the homeowner and his/her family.

Question 47: A 20 amp Class A GFCI receptacle outlet:

A: Provides 20 amps of overcurrent protection for equipment.
B: Will de-energize a circuit when it detects a current to ground of 6 mA or higher.
C: Is required to protect all 120 volt, 20 amp branch circuits that supply outlets in bedrooms and bathrooms.
D: Will trip on a 20 amp overload.

Question 48: 210.12 Arc-Fault Circuit-Interrupter Protection.

Question ID#: 10507.0

Combination type arc-fault circuit-interrupter protection is required in those locations in a dwelling that require arc-fault protection.

Branch circuits supplying most outlets in dwelling units must be protected by a ***combination*** AFCI. The combination AFCI "combines" the protection of the branch/feeder AFCI and the outlet circuit AFCI to provide broad arc fault protection. Combination AFCIs protect downstream branch circuit wiring, cord sets, and power-supply cords.

Combination AFCIs are designed to detect parallel arcing faults between grounded and ungrounded conductors as well as series arcing faults that occur between the ends of a break in either a grounded or an ungrounded conductor in a cable, cord or branch circuit.

In dwelling units all 120-volt, 15 and 20 amp branch-circuits that supply devices or outlets in the following locations are required to be protected by a combination type AFCI device: kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, or similar rooms or areas. The revised requirement provides protection for outlets for receptacles, luminaires, smoke detectors, and other equipment supplied by these branch-circuits. The only areas within dwelling units that do not have to be provided with AFCI protection are bathrooms, garages, and outdoor outlets.

An ***Exception*** exempts an individual fire alarm circuit from the AFCI requirements provided the circuit is installed in RMC, IMC, EMT, or steel sheathed cable, Type AC or Type MC.

Question 48: Which of the following statements best describes an arc-fault circuit interrupter?

A: Combination AFCI circuit breakers protect against series and parallel arc-faults.
B: AFCI protection is required for all indoor and outdoor receptacle outlets.
C: AFCI protection is not required in apartment units.
D: AFCI protection is required everywhere in a dwelling unit that GFCI protection is required.

Question 49:   210.20 Protecting Branch Circuit Continuous Loads.

Question ID#: 10508.0

Continuous loads are protected at no less than 125% of the calculated current.

A continuous load is any load which is on for 3 hours or more (Article 100).Â Overcurrent protection for continuous loads must be sized at no less thanÂ 125% of the load.

The increase in the fuse or breaker size is not because the current from a load increases when a load operates for more than 3 hours.Â If the voltage applied to a load is constant and if the load itself doesnâ€™t change, the current remains the same no matter how long the load operates.Â If a load draws 100 amps when it is first turned on, it will still be drawing 100 amps as long as it runs.Â

The problem with continuous loads is the heat that is generated in both conductors and in terminals where conductors are connected.Â Heat is produced any time current flows though conductors and through terminals; but, if conductors are sized correctly and the loads do not run continuously the heat produced is insignificant.Â However, the longer the current flows through a conductor or through terminals where it is connected the more they are heated.Â The NEC has found that loads operated for 3 hours or more cause significant heat to build up which adversely affects conductors, terminations, and overcurrent devices.Â Â Increasing the rating of overcurrent devices and the ampacity of conductors for continuous loads by 125% compensates for the heat buildup at the overcurrent device terminals.Â

Circuit breakers are thermal-magnetic devices; and, increased heat at the breaker terminals can cause a breaker to trip at a current below the breakerâ€™s rating. Â A larger breaker will compensate for the heat buildup of continuous loads by having a higher thermal trip point. Â A circuit breakerÂ´s thermal setting is to protect the circuit from overloads, not short circuits. Â Additional heat at the breaker terminals will fool the breaker into thinking there is an overload on the system and cause aÂ nuisance trip.

Â The NEC requires conductors for continuous load to be rated for 125% of the loadâ€™s nominal current.Â Increasing the ampacity of conductors for continuous loads helps reduce heat buildup on an overcurrent deviceâ€™s terminals. The conductor acts like a heat-sink and pulls heat away from the breaker terminals and reduces nuisance tripping caused by thermal buildup within the breaker.

Â 125% is written as a decimal by moving the decimal point to the left 2 places as follows: 125% = 1.25.Â You increase the breaker or conductor size for a continuous load by 125% by multiplying a loadâ€™s rated amperage by 1.25.Â

Example #1: Determine the right size breaker and conductor for a 40-amp continuous load as follows: 40-A x 1.25 = 50-A.Â Use a 50-A breaker and select a conductor that has an ampacity of at least 50-amps.

Example #2: Determine the largest continuous load that can be protected by a 60-amp breaker on a conductor that has a 60-amp rating as follows: 60 X .80 = 48-amps.Â Check that a load rated at 48-amps is the largest load that can be protected by a 60-amp breaker by multiplying 48 by 1.25: 48-A x 1.25 = 60-A.

Question 49:   What is the minimum standard circuit breaker rating for a 65 amp continuous load? (Standard circuit breaker ratings are listed in 240.6)

A: 65 amps.
B: 70 amps.
C: 80 amps.
D: 90 amps.

Question 50: 210.21 Overcurrent Protection for Outlet Devices.

Question ID#: 10509.0

When a branch circuit has a single receptacle, the receptacle rating cannot be smaller than the circuit rating.

The rating of a branch circuit is determined by the rating of the overcurrent device (210.3). If a branch circuit has a 15 amp load, 30 amp wire and a 20 amp circuit breaker, it is considered a 20 amp branch circuit.

If a 30 amp circuit breaker supplies a single outlet, then the rating of that receptacle must be 30 amps. The load on the receptacle cannot be more than 80% of the rating of the circuit breaker.

Table 210.24 summarizes the required overcurrent protection size for various receptacle ratings. (1) A 15 amp receptacle is protected at 15 amps. (2) A 15 or 20 amp rated receptacle is protected at 20 amps. (3) A 30 amp receptacle is protected at 30 amps. (4) A 40 or 50 amp receptacle is protected at 40 amps. (5) a 50 amp receptacle is protected at 50 amps.

Question 50: Which of the following is a Code violation for a single outlet branch circuit?

A: A 30 amp receptacle protected at 30 amps.
B: A 24 amp load on a 30 amp receptacle, protected at 30 amps.
C: A 40 amp receptacle protected at 50 amps.
D: A 12 amp load, on a 15 amp receptacle, protected at 15 amps.

Answer Sheet

Darken the correct answer. Sample: A ● C D

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49.) A B C D
50.) A B C D

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