Transformer secondary conductor protection is confusing to most electricians & electrical contractors. The tap rules for xfmrs (NEC 240.21.C) allow for xfmr secondary conductors to be tapped via the 10' rule & the 25' rule, to name a few. The intent of the tap rule is we can install a 10' or 25' tap conductor without over current protection (OCP) ***at the point the conductors receive their supply, which is at the xfmr lugs***. See below screen shots for clarification. Many electricians & contractors don't understand the intent of the xfmr secondary tap conductor rules & theory. Xfmr secondary conductors have to be protected. The primary OCP device (breaker) for the xfmr does not provide OCP for the xfmr secondary conductors. The xfmr primary breaker can provide xfmr protection for the xfmr secondary, but not the secondary conductors.

So in conclusion, we can apply the 10' & 25' tap rule for the seconday conductors, meaning no OCP device is required at the point the conductors receive their supply (at xfmr secondary lugs...X1, X2, X3, & X0). But an OCP device is still required at the end of the conductor tap, either via a separate disconnect, or a main breaker in the corresponding panel, as is reflected in the below screen shot. I have also attached a pdf (with bookmarks) for all the code sections that apply to this topic. Included in the pdf attachment are many pictures & commentary to this topic, for your reference.

COMMENTS ***5***

Similar to feeder taps, covered in the last issue, transformer secondary conductors can be every bit as confusing. Let's take a closer look at 240.21(C) to help clear up any misconceptions. Basic rules As with feeder taps, you can't use the rule provided in 240.4(B) for any transformer secondary conductor. Normally, you can use the next highest overcurrent protective device (OCPD) above the ampacity

Similar to feeder taps, covered in the last issue, transformer secondary conductors can be every bit as confusing. Let's take a closer look at 240.21(C) to help clear up any misconceptions.

Basic rules

As with feeder taps, you can't use the "next-size-up-OCPD" rule provided in 240.4(B) for any transformer secondary conductor. Normally, you can use the next highest overcurrent protective device (OCPD) above the ampacity of the conductors being protected, but not with transformer secondary conductors. The rule is the same because the physics are the same. As with feeder taps, the sizing of that transformer secondary conductor depends on its length and application.

Scenarios

When we demystified feeder taps in the previous issue, we presented the information in an arrangement that differs from what you see in the NEC. We also described an easy way to pick the correct scenario from the five possible. That same tip applies to transformer secondary conductors, which also have five scenarios.

Scenario 1: Secondary conductors from a feeder-tapped transformer.

Scenario 2: Outside secondary conductors.

Scenario 3: Secondary conductors not over 10 feet long.

Scenario 4: Secondary conductors 10 to 25 feet long.

Scenario 5: Secondary conductors 10 to 25 feet long, industrial installation.

To pick the right one, answer three easy questions:

1. Is the transformer outside? Choose Scenario 2.
2. Is the secondary conductor under 10 feet long or between 10 and 25 feet long? Choose Scenario 3 or 4, but choose Scenario 5 if it's an industrial installation.
3. Is the transformer supplied by a feeder tap? Choose Scenario 1.

Scenario 1: Secondary conductors from a feeder-tapped transformer

This one is simply a reference to 240.21(B)(3), so apply 240.21(B)(3) if you have a tap-supplied transformer.

Scenario 2: Outside secondary conductors

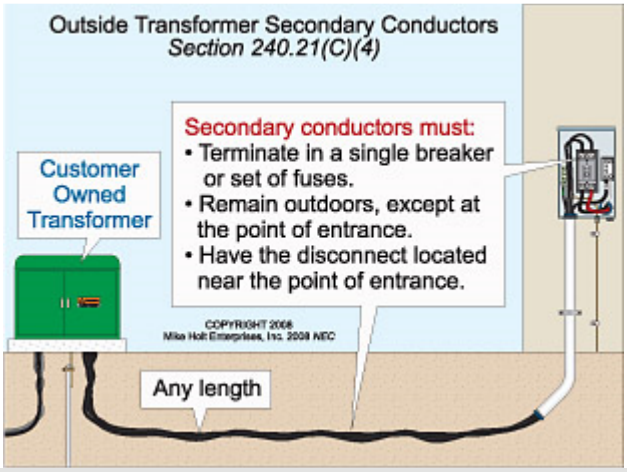

Fig. 1. Under certain conditions, outside secondary conductors can be of unlimited length, without overcurrent protection at the point they receive their supply.

Outside secondary conductors can be of unlimited length, without overcurrent protection at the point they receive their supply, if they (**Fig. 1**):

- Are suitably protected from physical damage in a raceway or manner approved by the authority having jurisdiction (AHJ).
- Terminate at a single circuit breaker (or a single set of fuses) that limit the load to the ampacity of the conductors.

Also:

- The OCPD for the ungrounded conductors must be an integral part of a disconnecting means or located immediately adjacent to it.
- The disconnecting means must be located at a readily accessible location near the point of entrance of the conductors.

Scenario 3: Secondary conductors not over 10 feet long

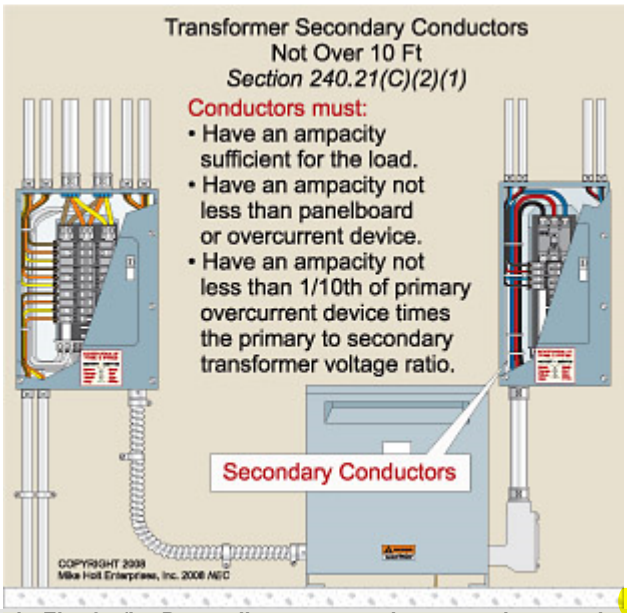

Fig. 2. Depending on ampacity, secondary conductors can be installed up to 10 feet long, without overcurrent protection at the point they receive their supply.

You can install secondary conductors up to 10 feet long, without overcurrent protection at the point they receive their supply, if they have an ampacity that is not less than (**Fig. 2**):

- The calculated load per Art. 220.
- The rating of the device supplied by the secondary conductors or the OCPD at the termination of the secondary conductors, and

- One-tenth the rating of the OCPD (protecting the primary of the transformer) multiplied by the primary-to-secondary transformer voltage ratio.

Also:

- Secondary conductors must not extend beyond the switchboard, panelboard, disconnecting means, or control devices they supply.
- Secondary conductors must be enclosed in a raceway.

Overcurrent protection is not required on the secondary side of the transformer to protect the secondary conductors, but overcurrent protection is required for branch-circuit panelboards. This OCPD must be on the secondary side of the transformer, and typically it's within the panelboard. The FPN under 240.21(C)(2)(3) refers you to 408.36 for the overcurrent protection requirements for panelboards.

Scenario 4: Secondary conductors 10 to 25 feet long

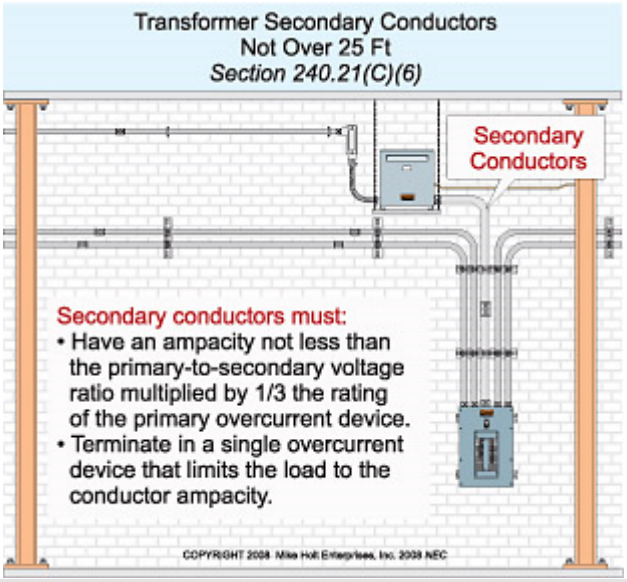

Fig. 3. Make sure you follow these guidelines when installing secondary conductors up to 25 feet long (without overcurrent protection at the point they receive their supply).

You can install secondary conductors up to 25 feet long, without overcurrent protection at the point they receive their supply, if they (**Fig. 3**):

- Have an ampacity that is at least the value of the primary-to-secondary voltage ratio multiplied by one-third of the rating of the OCPD that protects the primary of the transformer.
- Terminate in a single circuit breaker (or set of fuses) rated no more than the secondary conductor ampacity per 310.15 [Table 310.16].
- Are protected from physical damage by being enclosed in a manner approved by the AHJ (such as within a raceway).

Scenario 5: Taps 10 to 25 feet long, industrial installation

In an industrial application (only), you can install secondary conductors up to 25 feet long, without overcurrent protection at the point they receive their supply if:

- The ampacity of the secondary conductors is at least the value of the secondary current rating of the transformer.
- The sum of the ratings of the secondary OCPDs doesn't exceed the ampacity of the secondary conductors.
- The secondary OCPDs are grouped.
- The secondary conductors are protected from physical damage by being enclosed in a manner approved by the AHJ (such as within a raceway).

Test yourself

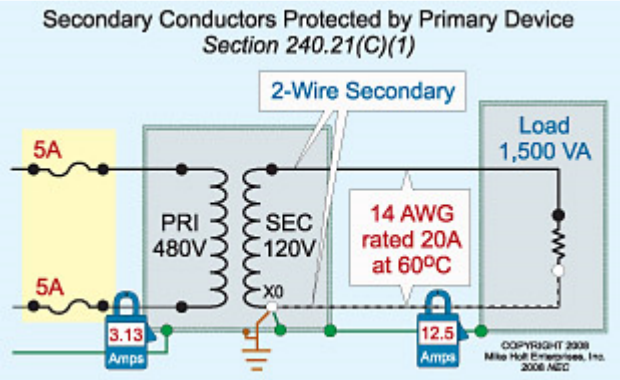

Fig. 4. The primary overcurrent device can protect the secondary conductors of a 2-wire system if the primary device does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary voltage ratio.

Now, let's see if you can put all this together to solve a practice problem. Question: What is the minimum size 15-foot secondary conductor required for a 2-wire, 480V to 120V indoor transformer rated 1.5kVA in an office installation (**Fig. 4**)?

Based on those two easy questions, you select Scenario 4. Then, you size the secondary to comply with Scenario 4 requirements.

To calculate the primary OCPD size, first we need to calculate the primary current. To do that, we need to know a couple of things:

VA = 1,500VA

E = 480V

Now we can calculate primary current:

Primary current = VA ÷ E = 1,500VA ÷ 480V = 3.13A

Now we can calculate primary protection. Per 450.3(B), it has to be 167% of the primary current. So, 3.13A × 1.67 = 5.22A. We can't apply the next size up rule, so we need a 5A OCPD.

To calculate the secondary conductor size:

- Determine the primary to secondary voltage ratio: 480V ÷ 120V = 4.
- Multiply the primary OCPD size by 1/3: 5 × 1/3 = 1.67.
- Multiply the two values together: 4 × 1.67 = 6.67A.
- Look in the 60°C, Table 310.16 for the smallest conductor with an ampacity larger than 6.67A.

Answer: 14AWG.

If you want more practice, try changing the transformer in the example above, and try different scenarios. For example, what if this is an industrial installation? Then, do the same thing but choose Scenario 5. You might find it useful to spend a few minutes trying different variations. This will help you better understand transformer tap conductor rules. They aren't difficult, if you can approach them methodically and apply those that fit your installation.

If those confusing transformer secondary rules have ever tripped your personal breaker, that's understandable. But now you can steer through those rules with confidence. The next time you need to size secondary conductors, stop to answer a couple of easy questions. Then, select the correct scenario for your installation.

With some transformer secondary conductors, you can use the primary OCPD to provide the overcurrent protection (just as you use the feeder OCPD to protect the feeder tap conductors). But, there's a catch: You can do this only for two specific transformer configurations. Those are:

- Single-phase transformer with 2-wire (single voltage) secondary.
- 3-phase delta-delta transformer with 3-wire (single voltage) secondary.

And:

- The OCPDs for those transformers must be sized per Art. 450.
- The secondary conductors must meet the sizing minimum required by the installation type described in 240.21(C).

(2) The ampacity of the conductors does not correspond with the standard ampere rating of a fuse or a circuit breaker without overload trip adjustments above its rating (but that shall be permitted to have other trip or rating adjustments).
(3) The next higher standard rating selected does not exceed 800 amperes.

Article 310 contains conductor ampacity tables based on conductor types, voltage rating, and conditions of use and application. For premises electrical installations operating at 2000 volts and below, the most widely used ampacity table is Table 310.15(B)(16). Section 240.6 lists the standard ratings of overcurrent devices. Where the ampacity of the conductor specified in these tables does not match the rating of the standard overcurrent device, 240.4(B) permits the use of the next larger standard overcurrent device. All three conditions must be met for this permission to apply. However, if the ampacity of a conductor corresponds with a standard rating in 240.6, the conductor is required to be protected by the standard rated device or by one with a smaller rating. For example, in Table 310.15(B)(16), 3 AWG, 75°C copper, Type THWN, the ampacity is listed as 100 amperes. That conductor would have to be protected by an OCPD rated not more than 100 amperes unless otherwise permitted in 240.4(E), (F), or (G).

Section 240.4(B) does not modify or change the allowable ampacity of the conductor — it only serves to provide a reasonable increase in the permitted OCPD rating where the allowable ampacity and the standard OCPD ratings do not correspond. The allowable ampacity of branch circuits or feeders rated 600 volts or less must always be capable of supplying the calculated load in accordance with the requirements of 210.19(A)(1) and 215.2(A)(1).

For services rated 1000 volts or less, the allowable ampacity of the service conductors must always be capable of supplying the calculated load in accordance with the requirements of 230.42(A).

For example, a 500-kcmil THWN copper conductor has an allowable ampacity of 380 amperes, specified in Table 310.15(B)(16). This conductor can supply a load not exceeding 380 amperes and, in accordance with 240.4(B), can be protected by a 400-ampere OCPD.

Section 240.4 references 310.15; therefore, all of the requirements of that section are applicable. Section 310.15(B)(7) permits the conductor types and sizes specified in that section to supply calculated loads based on the ratings specified. The service and main power feeder loads permitted to be supplied by the conductor types and sizes covered in 310.15(B)(7) exceed the conductor ampacities for the same conductor types and sizes specified in 310.15(B)(16). The overcurrent protection for these residential supply conductors is also permitted to be based on the increased rating allowed by 310.15(B)(7). Application of 310.15(B)(7) is permitted only for single-phase, 120/240-V, residential services and main power feeders. The increased ratings given in 310.15(B)(7) are based on the significant diversity inherent to most dwelling unit loads and the fact that only the two ungrounded service or feeder conductors are considered to be current carrying.

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

(D) Small Conductors. Unless specifically permitted in 240.4(E) or (G), the overcurrent protection shall not exceed that required by (D)(1) through (D)(7) after any correction factors for ambient temperature and number of conductors have been applied.

(1) 18 AWG Copper. 7 amperes, provided all the following conditions are met:

(1) Continuous loads do not exceed 5.6 amperes.
(2) Overcurrent protection is provided by one of the following:
   a. Branch-circuit-rated circuit breakers listed and marked for use with 18 AWG copper wire
   b. Branch-circuit-rated fuses listed and marked for use with 18 AWG copper wire
   c. Class CC, Class J, or Class T fuses

(2) 16 AWG Copper. 10 amperes, provided all the following conditions are met:

(1) Continuous loads do not exceed 8 amperes.
(2) Overcurrent protection is provided by one of the following:
   a. Branch-circuit-rated circuit breakers listed and marked for use with 16 AWG copper wire
   b. Branch-circuit-rated fuses listed and marked for use with 16 AWG copper wire
   c. Class CC, Class J, or Class T fuses

(3) 14 AWG Copper. 15 amperes

(4) 12 AWG Aluminum and Copper-Clad Aluminum. 15 amperes

(5) 12 AWG Copper. 20 amperes

(6) 10 AWG Aluminum and Copper-Clad Aluminum. 25 amperes

(7) 10 AWG Copper. 30 amperes

(E) Tap Conductors. Tap conductors shall be permitted to be protected against overcurrent in accordance with the following:

(1) 210.19(A)(3) and (A)(4), Household Ranges and Cooking Appliances and Other Loads
(2) 240.5(B)(2), Fixture Wire
(3) 240.21, Location in Circuit
(4) 368.17(B), Reduction in Ampacity Size of Busway
(5) 368.17(C), Feeder or Branch Circuits (busway taps)
(6) 430.53(D), Single Motor Taps

(F) Transformer Secondary Conductors. Single-phase (other than 2-wire) and multiphase (other than delta-delta, 3-wire) transformer secondary conductors shall not be considered to be protected by the primary overcurrent protective device. Conductors supplied by the secondary side of a single-phase

transformer having a 2-wire (single-voltage) secondary, or a three-phase, delta-delta connected transformer having a 3-wire (single-voltage) secondary, shall be permitted to be protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.

Section 240.4 requires conductors to be protected against overcurrent in accordance with their ampacity, and 240.21 requires that the protection be provided at the point the conductor receives its supply. Section 240.4(F) permits the secondary circuit conductors from a transformer to be protected by overcurrent devices in the primary circuit conductors of the transformer only in the following two special cases:

1. A transformer with a 2-wire primary and a 2-wire secondary, provided the transformer primary is protected in accordance with 450.3
2. A 3-phase, delta-delta-connected transformer having a 3-wire, single-voltage secondary, provided its primary is protected in accordance with 450.3

Except for those two special cases, transformer secondary conductors must be protected by the use of overcurrent devices, because the primary overcurrent devices do not provide such protection.

(G) Overcurrent Protection for Specific Conductor Applications. Overcurrent protection for the specific conductors shall be permitted to be provided as referenced in Table 240.4(G).

TABLE 240.4(G) *Specific Conductor Applications*

Conductor	Article	Section
Air-conditioning and refrigeration equipment circuit conductors	440, Parts III, VI	
Capacitor circuit conductors	460	460.8(B) and 460.25(A)–(D)
Control and instrumentation circuit conductors (Type ITC)	727	727.9
Electric welder circuit conductors	630	630.12 and 630.32
Fire alarm system circuit conductors	760	760.43, 760.45, 760.121, and Chapter 9, Tables 12(A) and 12(B)
Motor-operated appliance circuit conductors	422, Part II	
Motor and motor-control circuit conductors	430, Parts II, III, IV, V, VI, VII	
Phase converter supply conductors	455	455.7
Remote-control, signaling, and power-limited circuit conductors	725	725.43, 725.45, 725.121, and Chapter 9, Tables 11(A) and 11(B)
Secondary tie conductors	450	450.6

240.5 Protection of Flexible Cords, Flexible Cables, and Fixture Wires

Flexible cord and flexible cable, including tinsel cord and extension cords, and fixture wires shall be protected against overcurrent by either 240.5(A) or (B).

(A) Ampacities. Flexible cord and flexible cable shall be protected by an overcurrent device in accordance with their ampacity as specified in Table 400.5(A)(1) and Table 400.5(A)(2). Fixture wire shall be protected against overcurrent in accordance with its ampacity as specified in Table 402.5. Supplementary overcurrent protection, as covered in 240.10, shall be permitted to be an acceptable means for providing this protection.

(B) Branch-Circuit Overcurrent Device. Flexible cord shall be protected, where supplied by a branch circuit, in accordance with one of the methods described in 240.5(B)(1), (B)(3), or (B)(4). Fixture wire shall be protected, where supplied by a branch circuit, in accordance with 240.5(B)(2).

(1) Supply Cord of Listed Appliance or Luminaire. Where flexible cord or tinsel cord is approved for and used with a specific listed appliance or luminaire, it shall be considered to be protected when applied within the appliance or luminaire listing requirements. For the purposes of this section, a luminaire may be either portable or permanent.

A flexible cord connected to a listed appliance or portable lamp or used in a listed extension cord set is considered to be protected by the branch-circuit OCPD as long as the appliance, lamp, or extension cord is used in accordance with its listing requirements. These listing requirements are developed by the third-party testing and listing organizations with technical input from cord, appliance, and lamp manufacturers. For fixture wire, 240.5(B)(2) establishes a maximum protective device rating based on a minimum conductor size and a maximum conductor length.

(2) Fixture Wire. Fixture wire shall be permitted to be tapped to the branch-circuit conductor of a branch circuit in accordance with the following:

(1) 20-ampere circuits — 18 AWG, up to 15 m (50 ft) of run length
(2) 20-ampere circuits — 16 AWG, up to 30 m (100 ft) of run length

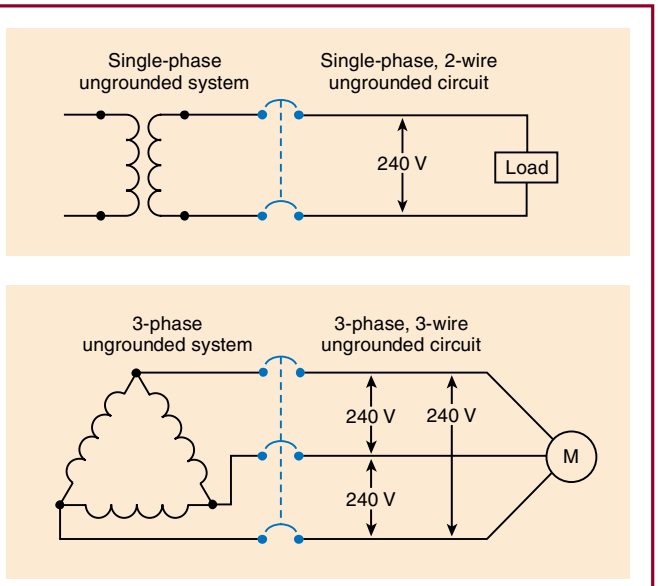

EXHIBIT 240.4 *Examples of circuits that require multipole common trip circuit breakers.*

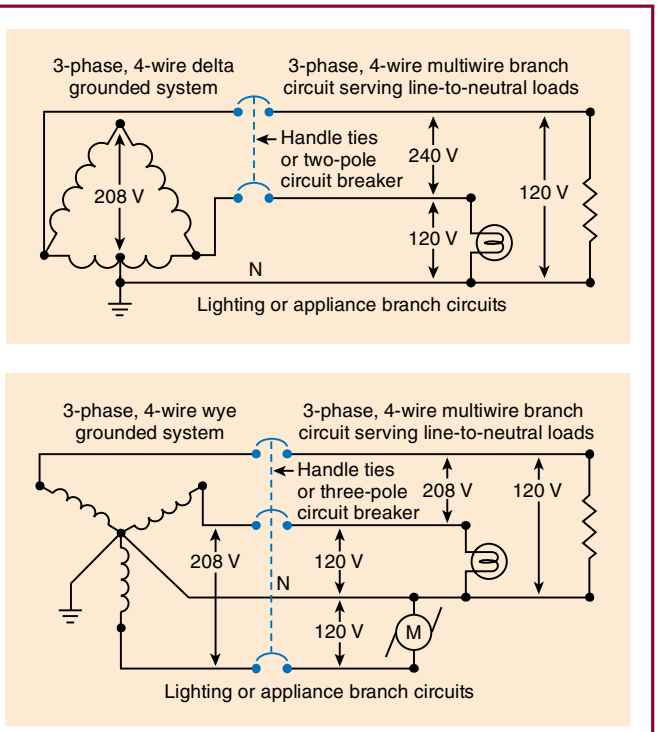

EXHIBIT 240.5 *Examples of circuits in which single-pole circuit breakers are permitted, because they open the ungrounded conductor of the circuit.*

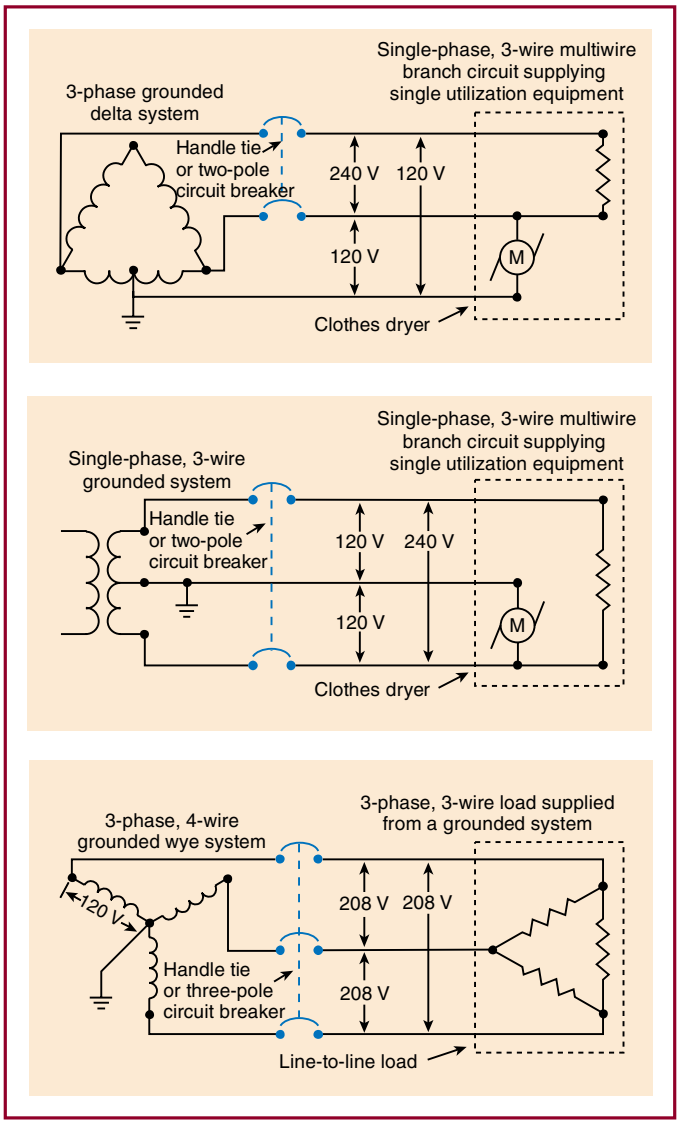

EXHIBIT 240.6 *Examples of circuits in which identified handle ties are permitted to provide the simultaneous disconnecting function.*

II. Location

240.21 Location in Circuit

Overcurrent protection shall be provided in each ungrounded circuit conductor and shall be located at the point where the conductors receive their supply except as specified in 240.21(A) through (H). Conductors supplied under the provisions of 240.21(A) through (H) shall not supply another conductor except through an overcurrent protective device meeting the requirements of 240.4.

(A) Branch-Circuit Conductors. Branch-circuit tap conductors meeting the requirements specified in 210.19 shall be permitted to have overcurrent protection as specified in 210.20.

(B) Feeder Taps. Conductors shall be permitted to be tapped, without overcurrent protection at the tap, to a feeder as specified in 240.21(B)(1) through (B)(5). The provisions of 240.4(B) shall not be permitted for tap conductors.

The use of the next highest standard-sized device allowed by 240.4(B) is not permitted for feeder tap conductor applications.

For instance, the use of a 500-kcmil THWN copper conductor [380 A, per Table 310.15(B)(16)] as a tap conductor to supply a 400-A rated device is not permitted, nor is it permitted to use the requirement in 240.6 to establish the relationship between the size of the tap conductor and the rating or setting of the feeder OCPD. If the feeder OCPD is 1200 A, a conductor with an ampacity of 400 A is required.

Exhibit 240.7 illustrates a 1/0 AWG, Type THW copper conductor [150 A, from Table 310.15(B)(16)] connected to a 3/0 AWG, Type THW copper feeder conductor with an ampacity of 200 A (increased in size to compensate for voltage drop) that is protected by a 150-A OCPD. Because the ampacity of the 1/0 AWG conductor is not exceeded by the rating of the overcurrent device, the 1/0 AWG conductor is not considered to be a tap conductor based on the definition of *tap conductors* in 240.2. The overcurrent device protects both sets of conductors in accordance with the basic rule of 240.4, and additional overcurrent protection is not required at the supply or termination point of the 1/0 AWG conductors. Both the 1/0 AWG and the 3/0 AWG conductors are protected by the 150-ampere circuit breaker. In this application, the 1/0 AWG conductors are not tap conductors as defined in 240.2.

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

(1) The ampacity of the tap conductors is

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

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

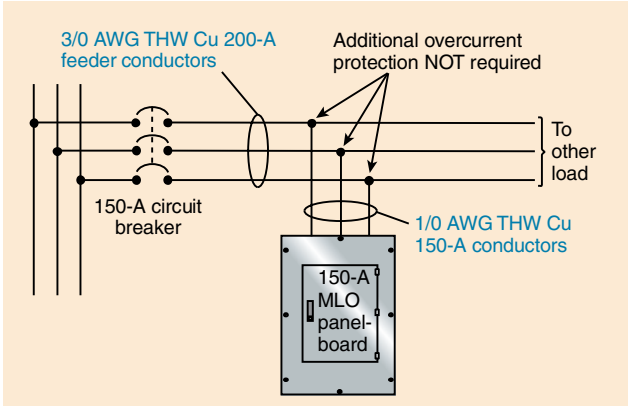

EXHIBIT 240.7 *An example in which the sets of 1/0 AWG and the 3/0 AWG conductors are both protected by the 150-ampere circuit breaker.*

Exception to b: Where listed equipment, such as a surge protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.

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

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

Exhibit 240.8 illustrates the feeder tap requirements of 240.21(B)(2). In this example, three 3/0 AWG, Type THW copper tap conductors are protected from physical damage by installation in a raceway. The tap conductors are not more than 25 feet in length between terminations, and the conductors are tapped from 500 kcmil, Type THW copper feeders and terminate in a single circuit breaker with a rating not greater than the ampacity of the tap conductors. The ampacity of the 3/0 AWG, Type THW copper conductor (200 A) is more than one-third the rating of the overcurrent device (400 A) protecting the feeder circuit. See Table 310.15(B)(16) for the ampacity of copper conductors in conduit. Note that the lengths specified in 240.21(B) and (C) apply to the conductors, not to a raceway enclosing the conductors or to the distance between the enclosures in which the tap conductors originate and terminate.

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

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

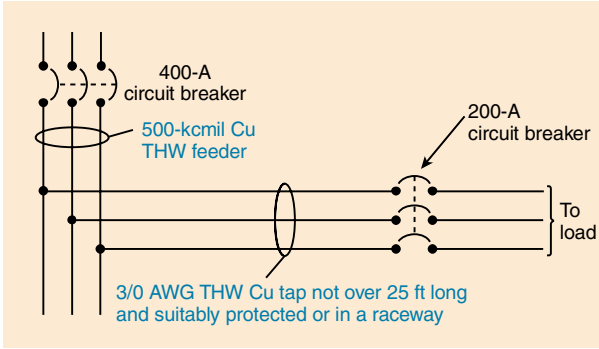

EXHIBIT 240.8 *An example in which the feeder taps terminate in a single circuit breaker.*

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

(1) The ampacity of the tap conductors is not less than one-third of the rating of the overcurrent device protecting the feeder conductors.
(2) The tap conductors terminate in a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This device shall be permitted to supply any number of additional overcurrent devices on its load side.
(3) The tap conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

(3) Taps Supplying a Transformer [Primary Plus Secondary Not over 7.5 m (25 ft) Long]. Where the tap conductors supply a transformer and comply with all the following conditions:

(1) The conductors supplying the primary of a transformer have an ampacity at least one-third the rating of the overcurrent device protecting the feeder conductors.
(2) The conductors supplied by the secondary of the transformer shall have an ampacity that is not less than the value of the primary-to-secondary voltage ratio multiplied by one-third of the rating of the overcurrent device protecting the feeder conductors.
(3) The total length of one primary plus one secondary conductor, excluding any portion of the primary conductor that is protected at its ampacity, is not over 7.5 m (25 ft).
(4) The primary and secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.
(5) The secondary conductors terminate in a single circuit breaker or set of fuses that limit the load current to not more than the conductor ampacity that is permitted by 310.15.

This section covers applications where the conductor length of 25 feet is applied to the primary and secondary conductors (using the length of one primary conductor plus the length of one secondary conductor for the measurement). The primary conductors are tapped to a feeder, and the secondary conductors are required to terminate in a single OCPD. Where the primary conductors are protected in accordance with their ampacity, 240.21(C)(6) permits the entire 25-foot measurement to be applied to the transformer secondary conductors. Exhibit 240.9 illustrates the conditions of 240.21(B)(3)(1) through (5). The overcurrent protection requirements of 408.36 for panelboards and 450.3(B) for transformers also apply.

(4) Taps over 7.5 m (25 ft) Long. Where the feeder is in a high bay manufacturing building over 11 m (35 ft) high at walls and the installation complies with all the following conditions:

(1) Conditions of maintenance and supervision ensure that only qualified persons service the systems.
(2) The tap conductors are not over 7.5 m (25 ft) long horizontally and not over 30 m (100 ft) total length.

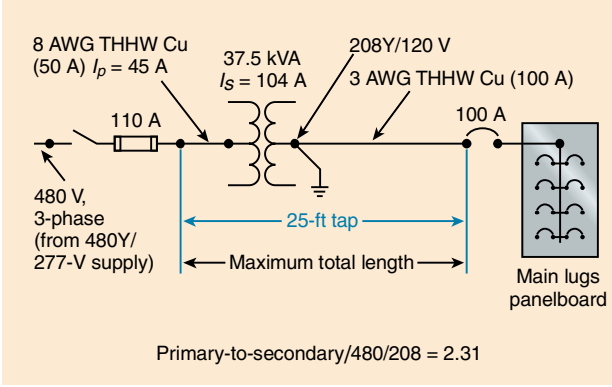

EXHIBIT 240.9 *An example in which the transformer feeder taps (primary plus secondary) are not over 25 feet long.*

(3) The ampacity of the tap conductors is not less than one-third the rating of the overcurrent device protecting the feeder conductors.
(4) The tap conductors terminate at a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
(5) The tap conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.
(6) The tap conductors are continuous from end-to-end and contain no splices.
(7) The tap conductors are sized 6 AWG copper or 4 AWG aluminum or larger.
(8) The tap conductors do not penetrate walls, floors, or ceilings.
(9) The tap is made no less than 9 m (30 ft) from the floor.

This section permits a tap of 100 feet for manufacturing buildings with walls that are over 35 feet high where the tap connection is made not less than 30 feet from the floor and conditions of maintenance and supervision ensure that only qualified persons service these systems. Exhibit 240.10 illustrates such an installation.

(5) Outside Taps of Unlimited Length. Where the conductors are located outside of a building or structure, except at the point of load termination, and comply with all of the following conditions:

(1) The tap conductors are protected from physical damage in an approved manner.
(2) The tap conductors terminate at a single circuit breaker or a single set of fuses that limits the load to the ampacity of the tap conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.

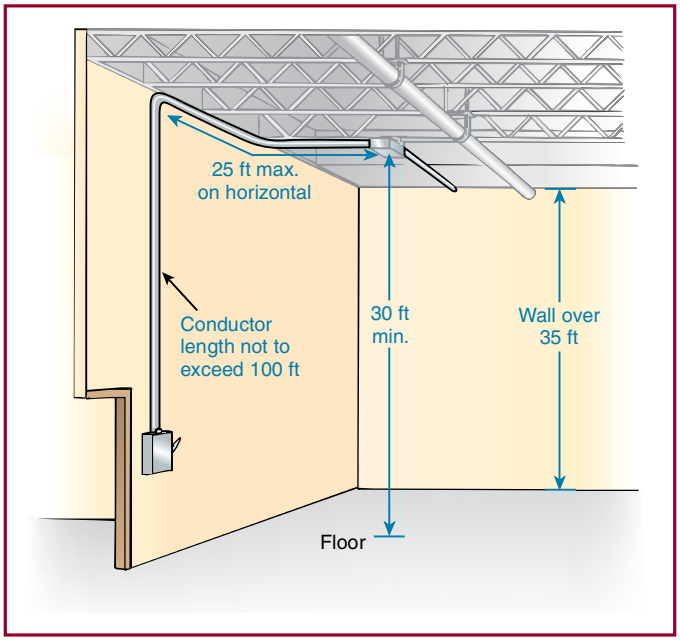

EXHIBIT 240.10 *An illustration of a feeder tap in a high bay building.*

(3) The overcurrent device for the tap conductors is an integral part of a disconnecting means or shall be located immediately adjacent thereto.

(4) The disconnecting means for the tap conductors is installed at a readily accessible location complying with one of the following:

a. Outside of a building or structure
b. Inside, nearest the point of entrance of the tap conductors
c. Where installed in accordance with 230.6, nearest the point of entrance of the tap conductors

Section 240.21(B)(5) is a tap conductor requirement that is similar in some respects to an installation of service conductors. The conductors are supplied from a feeder at an outdoor location and run to a building or structure without limitations on the tap conductor length. The tap conductors must be protected against physical damage and must terminate in a single, fused disconnect or a single circuit breaker with a rating that does not exceed the ampacity of the tap conductors. This OCPD provides overload protection for the tap conductors. The fused switch or circuit breaker is installed at a readily accessible location either inside or outside a building or structure and is subject to the applicable requirements covering feeder disconnecting means in Part II of Article 225. The fused switch or circuit breaker is required to be installed inside or outside of the building or structure at a point nearest to where the tap conductors enter the building or structure.

(C) Transformer Secondary Conductors. A set of conductors feeding a single load, or each set of conductors feeding separate loads, shall be permitted to be connected to a transformer secondary, without overcurrent protection at the secondary, as specified in 240.21(C)(1) through (C)(6). The provisions of 240.4(B) shall not be permitted for transformer secondary conductors.

Informational Note: For overcurrent protection requirements for transformers, see 450.3.

The six applications covered in 240.21(C) permit transformer secondary conductors without an OCPD at the point the secondary conductors receive their supply.

Like 240.21(B) for conductors tapped to a feeder, 240.21(C) specifically prohibits application of 240.4(B) with transformer secondary conductors covered by the requirements of 240.21(C)(1) through (C)(6). See the commentary for 240.21(B).

The secondary terminals of a transformer are permitted to supply one or more than one set of secondary conductors. The first sentence specifies that the requirements apply to "a set of conductors feeding a single load" or "to each set of conductors feeding separate loads." For example, the secondary terminals could supply two separate sets of secondary conductors that feed two panelboards. One set of conductors could be installed using the 25-foot secondary conductor rule of 240.21(C)(6), while the other set of conductors could be installed using the 10-foot secondary conductor rule of 240.21(C)(2). Each set is treated individually in applying the applicable secondary conductor requirement. It is necessary to coordinate the secondary conductor protection requirements of 240.21(C) and, where applicable, the transformer secondary protection requirements in 450.3(A) and (B).

(1) Protection by Primary Overcurrent Device. Conductors supplied by the secondary side of a single-phase transformer having a 2-wire (single-voltage) secondary, or a three-phase, delta-delta connected transformer having a 3-wire (single-voltage) secondary, shall be permitted to be protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.

Single-phase (other than 2-wire) and multiphase (other than delta-delta, 3-wire) transformer secondary conductors are not considered to be protected by the primary overcurrent protective device.

(2) Transformer Secondary Conductors Not over 3 m (10 ft) Long. If the length of secondary conductor does not exceed 3 m (10 ft) and complies with all of the following:

(1) The ampacity of the secondary conductors is

a. Not less than the combined calculated loads on the circuits supplied by the secondary conductors, and
b. Not less than the rating of the equipment containing an overcurrent device(s) supplied by the secondary conductors or not less than the rating of the overcurrent protective device at the termination of the secondary conductors.

Exception: Where listed equipment, such as a surge protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.

(2) The secondary conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.
(3) The secondary conductors are enclosed in a raceway, which shall extend from the transformer to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices or to the back of an open switchboard.
(4) For field installations where the secondary conductors leave the enclosure or vault in which the supply connection is made, the rating of the overcurrent device protecting the primary of the transformer, multiplied by the primary to secondary transformer voltage ratio, shall not exceed 10 times the ampacity of the secondary conductor.

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

The minimum size requirement in 240.21(C)(2) for 10-foot transformer secondary conductors establishes a relationship between the size of the ungrounded secondary conductors and the rating of the transformer primary OCPD similar to the sizing requirements applied in 240.21(B)(1) for 10-foot feeder tap conductors. This size–rating relationship is necessary because the transformer primary device also provides short-circuit ground-fault protection for the transformer secondary conductors. It is necessary to also ensure that the ampacity of the conductors is adequate for the calculated load and is not less than the rating of the device or OCPD in which the conductors terminate. The following example illustrates the application of this requirement.

Calculation Example

Apply the 10-foot secondary conductor protection criteria of 240.21(C)(2) to a transformer rated 75 kVA, 3-phase, 480 V primary to 208Y/120 V secondary. The transformer primary OCPD is rated 125 A. Determine the minimum secondary conductor size for this installation.

Solution

STEP 1. Determine 1/10 of the primary OCPD rating using the following calculation:

$$125 \text{ A} \div 10 = 12.5 \text{ A}$$

STEP 2. Determine the line-to-line primary-to-secondary voltage ratio:

$$\left(\frac{480}{208}\right) = 2.31$$

STEP 3. Determine the minimum ampacity for ungrounded transformer secondary conductor:

$$12.5 \text{ A} \times 2.31 = 29 \text{ A} \rightarrow 10 \text{ AWG copper THWN}$$
[Table 310.15(B)(16)]: 30 A from 60°C column

A 10 AWG copper conductor is permitted to be tapped from the secondary of this transformer with primary overcurrent protection rated 125 A. The load supplied by this secondary conductor cannot exceed the conductor's allowable ampacity from Table 310.15(B)(16) coordinated with the temperature rating of the conductor terminations in accordance with 110.14(C)(1)(a).

(3) Industrial Installation Secondary Conductors Not over 7.5 m (25 ft) Long. For the supply of switchgear or switchboards in industrial installations only, where the length of the secondary conductors does not exceed 7.5 m (25 ft) and complies with all of the following:

(1) Conditions of maintenance and supervision ensure that only qualified persons service the systems.
(2) The ampacity of the secondary conductors is not less than the secondary current rating of the transformer, and the sum of the ratings of the overcurrent devices does not exceed the ampacity of the secondary conductors.
(3) All overcurrent devices are grouped.
(4) The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

(4) Outside Secondary Conductors. Where the conductors are located outdoors of a building or structure, except at the point of load termination, and comply with all of the following conditions:

(1) The conductors are protected from physical damage in an approved manner.
(2) The conductors terminate at a single circuit breaker or a single set of fuses that limit the load to the ampacity of the conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
(3) The overcurrent device for the conductors is an integral part of a disconnecting means or shall be located immediately adjacent thereto.
(4) The disconnecting means for the conductors is installed at a readily accessible location complying with one of the following:
   a. Outside of a building or structure
   b. Inside, nearest the point of entrance of the conductors
   c. Where installed in accordance with 230.6, nearest the point of entrance of the conductors.

(5) Secondary Conductors from a Feeder Tapped Transformer. Transformer secondary conductors installed in accordance with 240.21(B)(3) shall be permitted to have overcurrent protection as specified in that section.

(6) Secondary Conductors Not over 7.5 m (25 ft) Long. Where the length of secondary conductor does not exceed 7.5 m (25 ft) and complies with all of the following:

(1) The secondary conductors shall have an ampacity that is not less than the value of the primary-to-secondary voltage ratio multiplied by one-third of the rating of the overcurrent device protecting the primary of the transformer.
(2) The secondary conductors terminate in a single circuit breaker or set of fuses that limit the load current to not more than the conductor ampacity that is permitted by 310.15.
(3) The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

(D) Service Conductors. Service conductors shall be permitted to be protected by overcurrent devices in accordance with 230.91.

(E) Busway Taps. Busways and busway taps shall be permitted to be protected against overcurrent in accordance with 368.17.

(F) Motor Circuit Taps. Motor-feeder and branch-circuit conductors shall be permitted to be protected against overcurrent in accordance with 430.28 and 430.53, respectively.

(G) Conductors from Generator Terminals. Conductors from generator terminals that meet the size requirement in 445.13 shall be permitted to be protected against overload by the generator overload protective device(s) required by 445.12.

(H) Battery Conductors. Overcurrent protection shall be permitted to be installed as close as practicable to the storage battery terminals in an unclassified location. Installation of the overcurrent protection within a hazardous (classified) location shall also be permitted.

240.22 Grounded Conductor

No overcurrent device shall be connected in series with any conductor that is intentionally grounded, unless one of the following two conditions is met:

(1) The overcurrent device opens all conductors of the circuit, including the grounded conductor, and is designed so that no pole can operate independently.
(2) Where required by 430.36 or 430.37 for motor overload protection.

240.23 Change in Size of Grounded Conductor

Where a change occurs in the size of the ungrounded conductor, a similar change shall be permitted to be made in the size of the grounded conductor.

The size of the grounded circuit conductor may be increased (e.g., because of voltage-drop problems) or reduced to correspond to a reduction made in the size of the ungrounded circuit conductor(s), as in the case of feeder tap conductors, provided that the grounded and ungrounded conductors comprise the same circuit.

240.24 Location in or on Premises

(A) Accessibility. Overcurrent devices shall be readily accessible and shall be installed so that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, is not more than 2.0 m (6 ft 7 in.) above the floor or working platform, unless one of the following applies:

(1) For busways, as provided in 368.17(C).
(2) For supplementary overcurrent protection, as described in 240.10.
(3) For overcurrent devices, as described in 225.40 and 230.92.
(4) For overcurrent devices adjacent to utilization equipment that they supply, access shall be permitted to be by portable means.

This section recognizes the need for overcurrent protection in locations that are not readily accessible, such as above suspended ceilings. Overcurrent devices are permitted to be located so that they are not readily accessible, as long as they are located next to the appliance, motor, or other equipment they supply and can be reached by using a ladder. For the purposes of this requirement, ready access to the operating handle of a fusible switch or circuit breaker is considered to be not more than 6 feet 7 inches above the finished floor or working platform.

The measurement is made from the center of the device operating handle where the handle is at its highest position. This text parallels the requirement of 404.8(A), which applies to all switches and circuit breakers used as switches. For information regarding the accessibility of supplementary overcurrent devices, refer to 240.10.

(B) Occupancy. Each occupant shall have ready access to all overcurrent devices protecting the conductors supplying that occupancy, unless otherwise permitted in 240.24(B)(1) and (B)(2).

(1) Service and Feeder Overcurrent Devices. Where electric service and electrical maintenance are provided by the building management and where these are under continuous building management supervision, the service overcurrent devices and feeder overcurrent devices supplying more than one occupancy shall be permitted to be accessible only to authorized management personnel in the following:

(1) Multiple-occupancy buildings
(2) Guest rooms or guest suites

(2) Branch-Circuit Overcurrent Devices. Where electric service and electrical maintenance are provided by the building management and where these are under continuous building management supervision, the branch-circuit overcurrent devices supplying any guest rooms or guest suites without permanent

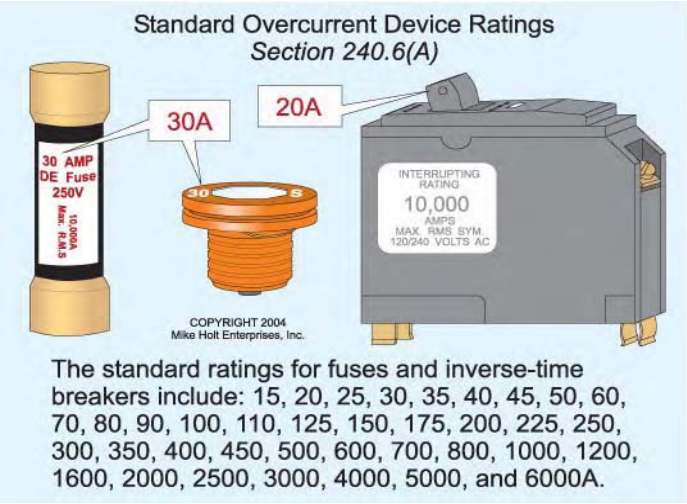

Figure 240–11

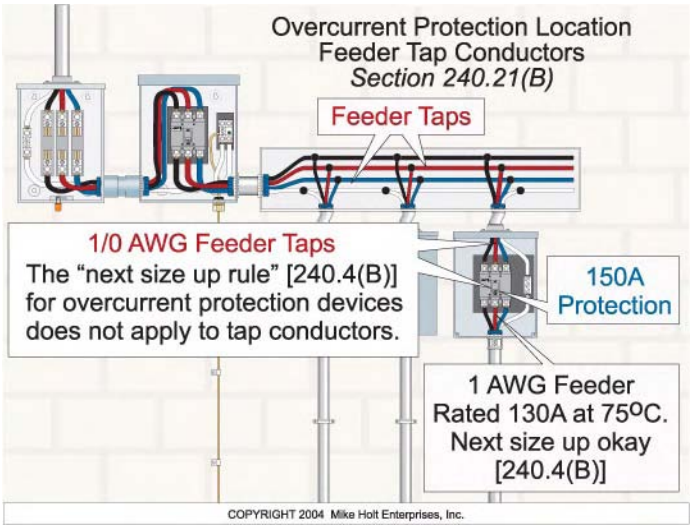

Figure 240–18

(B) Adjustable Circuit Breakers. The ampere rating of an adjustable circuit breaker is equal to its maximum long-time pickup current setting.

(C) Restricted-Access, Adjustable-Trip Circuit Breakers. The ampere rating of adjustable-trip circuit breakers that have restricted access to the adjusting means is equal to their adjusted long-time pickup current settings.

35 240.21 Overcurrent Protection Location in Circuit

Except as permitted by (A) through (G), overcurrent protection devices must be placed at the point where the branch or feeder conductors receive their power.

A tap conductor cannot supply another tap conductor. In other words, you cannot make a tap from a tap.

(A) Branch-Circuit Taps. Branch-circuit taps installed in accordance with 210.19 are permitted.

(B) Feeder Tap Conductors. Conductors can be tapped from a feeder if they are installed in accordance with (1) through (5). The "next size up protection rule" for conductors contained in 240.4(B) is not permitted to be used for feeder tap conductors.

Question: *What size tap conductor would be required for a 150A circuit breaker if the calculated continuous load was 100A?* Figure 240–18

(a) 3 AWG, rated 100A *(b) 2 AWG, rated 115A*
(c) 1 AWG, rated 130A *(d) 1/0 AWG, rated 150A*

Answer: *(d) 1/0 AWG tap conductors would be required to supply the circuit breaker.*

AUTHOR'S COMMENT: A 150A protection device is permitted to protect a 1 AWG conductor, which is rated 130A [Table 310.16], on the load side of the 150A circuit breaker [240.4(B)].

(1) 10-Foot Feeder Tap. Feeder tap conductors up to 10 ft long are permitted without overcurrent protection if installed as follows: Figure 240–19

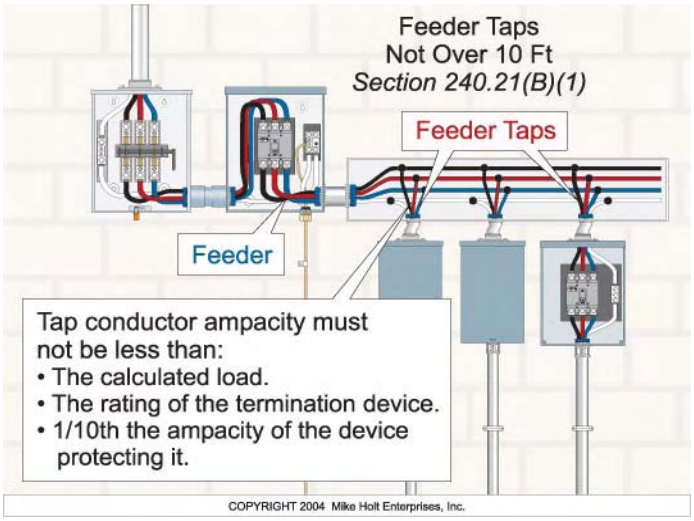

Figure 240–19

(1) The ampacity of the tap conductor must not be less than:

a. The calculated load in accordance with Article 220, and

b. The rating of the device supplied by the tap conductors or the overcurrent protective device at the termination of the tap conductors.

(2) The tap conductors must not extend beyond the equipment they supply.

(3) The tap conductors must be installed in a raceway if they leave the enclosure.

(4) The tap conductors must have an ampacity not less than 10 percent of the ampacity of the overcurrent protection device that protects the feeder.

(2) 25-Foot Feeder Tap. Feeder tap conductors up to 25 ft long are permitted without overcurrent protection if installed as follows: Figure 240–20

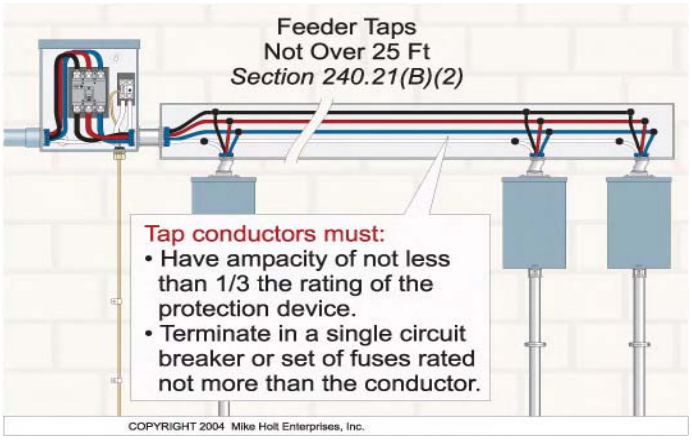

Figure 240–20

(1) The ampacity of the tap conductors must not be less than one-third the ampacity of the overcurrent protection device that protects the feeder.

(2) The tap conductors terminate in a single circuit breaker, or set of fuses rated no greater than the tap conductor ampacity in accordance with 310.15 [Table 310.16].

(3) The tap conductors must be protected from physical damage by being enclosed in a manner approved by the authority having jurisdiction, such as within a raceway.

(3) Taps Supplying a Transformer. Feeder tap conductors that supply a transformer must be installed as follows:

(1) The primary tap conductors must have an ampacity not less than one-third the ampacity of the overcurrent protection device.

(2) The secondary conductors must have an ampacity that, when multiplied by the ratio of the primary-to-secondary voltage, is at least one-third the rating of the overcurrent device that protects the feeder conductors.

(3) The total length of the primary and secondary conductors must not exceed 25 ft.

(4) Primary and secondary conductors must be protected from physical damage by being enclosed in a manner approved by the authority having jurisdiction, such as within a raceway.

(5) Secondary conductors terminate in a single circuit breaker, or set of fuses rated no greater than the tap conductor ampacity in accordance with 310.15 [Table 310.16].

(4) 100 Ft Tap. Feeder tap conductors in a high bay manufacturing building (over 35 ft high at walls) can be run up to 100 ft without overcurrent protection if installed as follows:

(1) Supervision ensures that only qualified persons service the systems.

(2) Tap conductors aren't over 25 ft long horizontally and not over 100 ft in total length.

(3) The ampacity of the tap conductors must not be less than one-third the ampacity of the overcurrent protection device that protects the feeder.

(4) The tap conductors terminate in a single circuit breaker or set of fuses rated no greater than the tap conductor ampacity in accordance with 310.15 [Table 310.16].

(5) Tap conductors must be protected from physical damage by being enclosed in a manner approved by the authority having jurisdiction, such as within a raceway.

(6) Tap conductors contain no splices.

(7) Tap conductors are 6 AWG copper or 4 AWG aluminum or larger.

(8) Tap conductors do not penetrate walls, floors, or ceilings.

(9) The tap is made no less than 30 ft from the floor.

(5) Outside Feeder Tap of Unlimited Length Rule. Outside feeder tap conductors can be of unlimited length without overcurrent protection at the point they receive their supply if installed as follows: Figure 240–21

(1) The tap conductors must be suitably protected from physical damage in a raceway or manner approved by the authority having jurisdiction.

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

(3) The overcurrent device for the tap conductors must be an integral part of the disconnecting means or it must be located immediately adjacent to it.

(4) The disconnecting means must be located at a readily accessible location either outside the building or structure, or nearest the point of entry of the conductors.

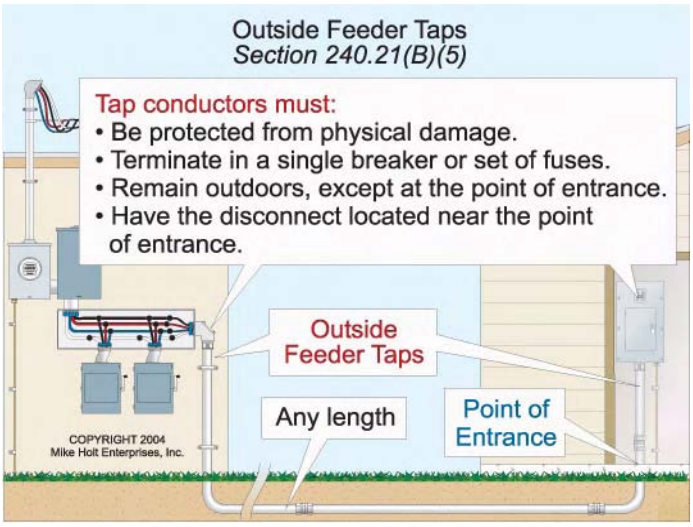

Figure 240–21

(C) Transformer Secondary Conductors. Each set of conductors feeding separate loads can be connected to a transformer secondary, without overcurrent protection at the secondary, in accordance with (1) through (6).

The "next size up protection rule" for conductors contained in 240.4(B) is not permitted to be used for transformer secondary conductors. Figure 240–22

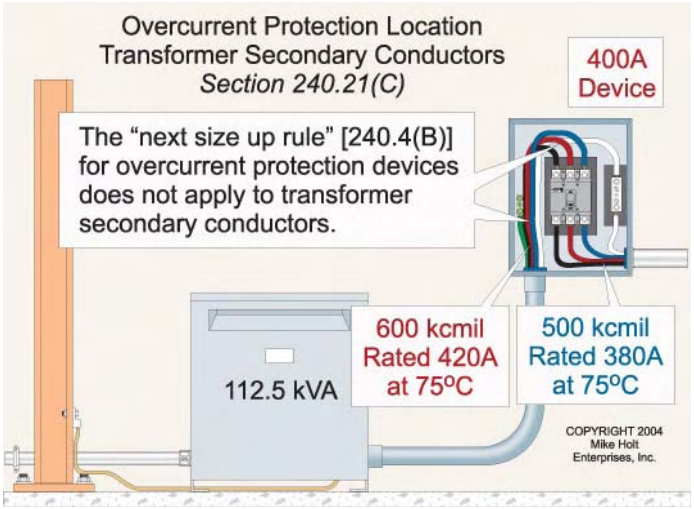

Figure 240–22

(1) Protection by Primary Overcurrent Device. The primary overcurrent protection device sized in accordance with 450.3(B) can protect the secondary conductors of a 2-wire system or a 3-wire three-phase, delta/delta connected system, provided the primary protection device does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.

Question: *What is the minimum size secondary conductor required for a 2-wire 480V to 120V transformer rated 1.5 kVA?* Figure 240–23

(a) 16 AWG (b) 14 AWG (c) 12 AWG (d) 10 AWG

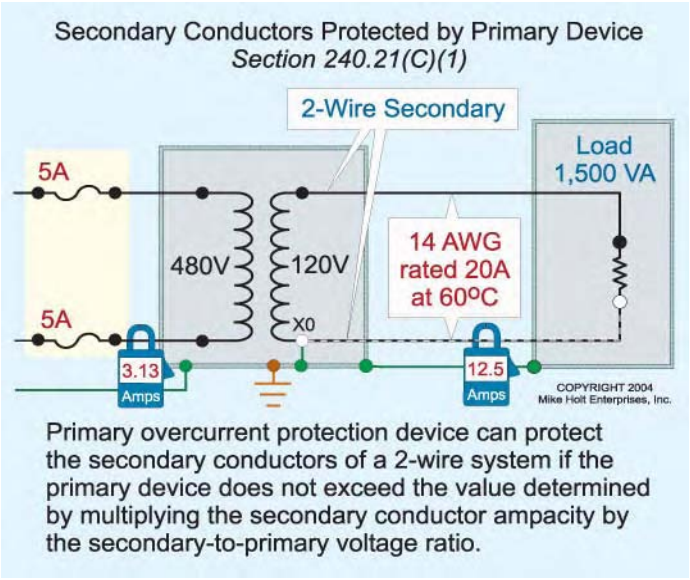

Figure 240–23

Answer: *(b) 14 AWG*

Primary Current = VA/E
VA = 1,500 VA
E = 480V

Primary Current = 1,500 VA/480V
Primary Current = 3.13A
Primary Protection [450.3(B)] = 3.13A x 1.67 = 5.22A or 5A Fuse

Secondary Current = 1,500 VA/120V
Secondary Current = 12.5A
Secondary Conductor = 14 AWG, rated 20A at 60°C, Table 310.16

The 5A primary protection device can be used to protect 14 AWG secondary conductors because it doesn't exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio (5A = 20A x 120V/480V).

(2) 10 Ft Secondary Conductor. Secondary conductors can be run up to 10 ft without overcurrent protection if installed as follows: Figure 240–24

(1) The ampacity of the secondary conductor must not be less than:

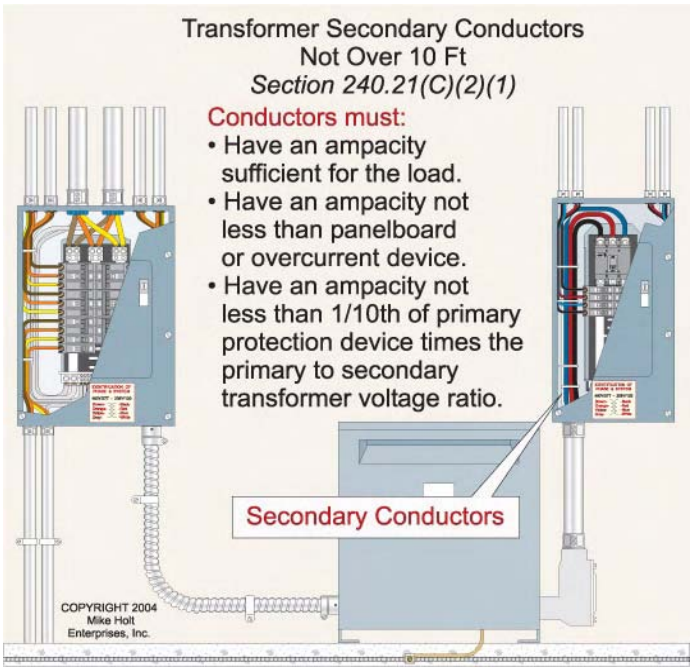

Figure 240–24

a. The calculated load in accordance with Article 220,

b. The rating of the device supplied by the secondary conductors or the overcurrent protective device at the termination of the secondary conductors, and

c. Not less than one-tenth the rating of the overcurrent device protecting the primary of the transformer, multiplied by the primary-to-secondary transformer voltage ratio.

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

(3) The secondary conductors must be enclosed in a raceway.

AUTHOR'S COMMENT: Lighting and appliance branch-circuit panelboards must have overcurrent protection located on the secondary side of the transformer [408.36(D)]. Figure 240–25

(3) Industrial Installation Secondary Conductors not Over 25 Ft. For industrial installations, secondary conductors can be run up to 25 ft without overcurrent protection if installed as follows:

(1) The secondary conductor ampacity isn't less than:
- The secondary current rating of the transformer, and
- The sum of the ratings of the overcurrent devices.

(2) Secondary overcurrent devices are grouped.

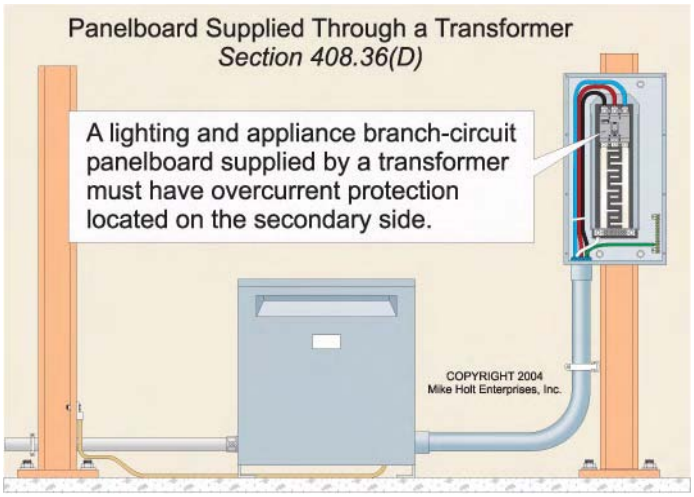

Figure 240–25

(3) Secondary conductors must be protected from physical damage by being enclosed in a raceway or manner approved by the authority having jurisdiction.

(4) Outside Secondary Conductors of Unlimited Length. Outside secondary conductors can be of unlimited length without overcurrent protection at the point they receive their supply if they are installed as follows: Figure 240–26

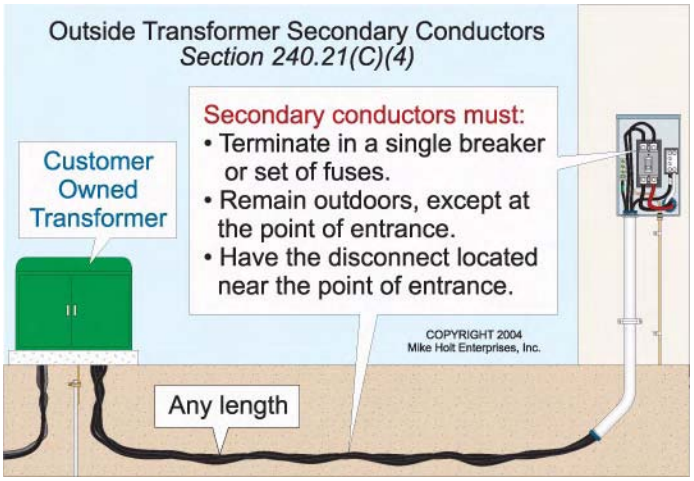

Figure 240–26

(1) The conductors must be suitably protected from physical damage in a raceway or manner approved by the authority having jurisdiction.

(2) The conductors terminate at a single circuit breaker or a single set of fuses that limit the load to the ampacity of the conductors.

(3) The overcurrent device for the ungrounded conductors must be an integral part of a disconnecting means or it must be located immediately adjacent thereto.

(4) The disconnecting means must be located at a readily accessible location that complies with one of the following:

a. Outside of a building or structure.

b. Inside, nearest the point of entrance of the conductors.

c. Where installed in accordance with 230.6, nearest the point of entrance of the conductors.

(5) Secondary Conductors from a Feeder Tapped Transformer. Transformer secondary conductors must be installed in accordance with 240.21(B)(3).

(6) 25-Foot Secondary Conductor. Secondary conductors can be run up to 25 ft without overcurrent protection if installed as follows: Figure 240–27

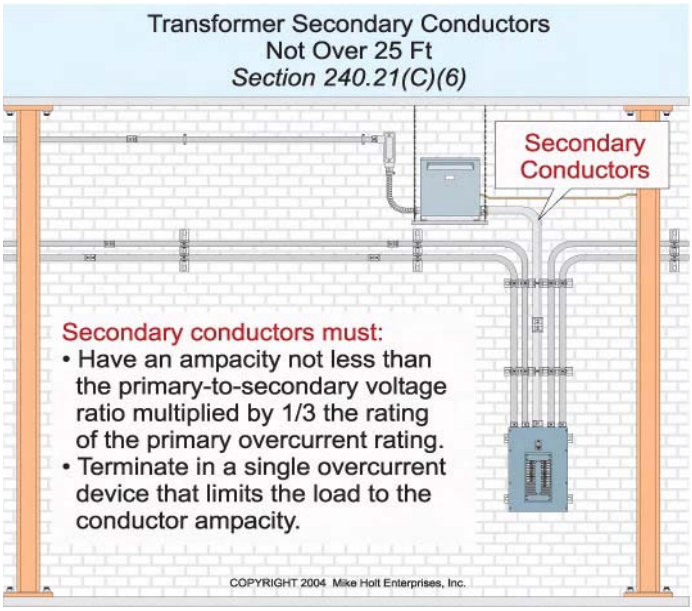

Figure 240–27

(1) The secondary conductors must have an ampacity that when multiplied by the ratio of the primary-to-secondary voltage isn't less than one-third the rating of the overcurrent device that protects the primary of the transformer.

(2) Secondary conductors terminate in a single circuit breaker or set of fuses rated no greater than the tap conductor ampacity in accordance with 310.15 [Table 310.16].

(3) The secondary conductors must be protected from physical damage by being enclosed in a manner approved by the authority having jurisdiction, such as within a raceway.

Question: *True or False. A 112.5 kVA, 120/208V three-phase transformer would be required to terminate in a 400A protection device, with 600 kcmil conductors from the secondary to the line side of the disconnect, but 500 kcmil conductors could be used on the load side!*

(a) True (b) False

Answer: *(a) True*

Secondary Current = VA/(E x 1.732)
Secondary Current = 112,500 VA/208 x 1.732
Secondary Current = 313A

Secondary Overcurrent Protection Device Size = 313 x 1.25 [215.3]
Secondary Overcurrent Protection Device Size = 391
Secondary Overcurrent Protection Device Size = 400A [240.6]

Secondary Conductor Size = 600 kcmil rated 420A, Table 310.16 at 75°C

Conductors leaving the 400A protection device can be 500 kcmil. See 240.4(B).

(D) Service Conductors. Service-entrance conductors must be protected against overload in accordance with 230.91.

ARTICLE 450 Transformers and Transformer Vaults (Including Secondary Ties)

450.1 Scope

This article covers the installation of all transformers.

Exception No. 1: Current transformers.

See 110.23 for the requirement on energized current transformers that are not in use.

Exception No. 2: Dry-type transformers that constitute a component part of other apparatus and comply with the requirements for such apparatus.

Exception No. 3: Transformers that are an integral part of an X-ray, high-frequency, or electrostatic-coating apparatus.

Exception No. 4: Transformers used with Class 2 and Class 3 circuits that comply with Article 725.

Exception No. 5: Transformers for sign and outline lighting that comply with Article 600.

Exception No. 6: Transformers for electric-discharge lighting that comply with Article 410.

Exception No. 7: Transformers used for power-limited fire alarm circuits that comply with Part III of Article 760.

Exception No. 8: Transformers used for research, development, or testing, where effective arrangements are provided to safeguard persons from contacting energized parts.

This article covers the installation of transformers dedicated to supplying power to a fire pump installation as modified by Article 695.

This article also covers the installation of transformers in hazardous (classified) locations as modified by Articles 501 through 504.

I. General Provisions

450.2 Definition

For the purpose of this article, the following definition shall apply.

Transformer. An individual transformer, single- or polyphase, identified by a single nameplate, unless otherwise indicated in this article.

450.3 Overcurrent Protection

Overcurrent protection of transformers shall comply with 450.3(A), (B), or (C). As used in this section, the word *transformer* shall mean a transformer or polyphase bank of two or more single-phase transformers operating as a unit.

Informational Note No. 1: See 240.4, 240.21, 240.100, and 240.101 for overcurrent protection of conductors.

The requirements for overcurrent protection of transformer secondaries apply only to the protection of transformers, not to the protection of conductors. The sections in Article 240 referenced in the informational note apply only to the protection of conductors, not to the protection of transformers. The overcurrent protection required by Article 450 may also satisfy the requirements in Article 240 for conductor protection, and vice versa, but it is also possible that they do not.

The overcurrent protection required for transformers may not provide satisfactory protection for the primary and secondary conductors. Where polyphase transformers are involved, primary and secondary conductors are usually not properly protected. The primary overcurrent device provides short-circuit protection for the primary conductors and a degree of overload protection for the transformer, and secondary overcurrent devices prevent the transformer and secondary conductors from being overloaded.

A transformer is considered the point of supply, and the conductors it supplies must be protected in accordance with their ampacity. Section 240.4(F) permits the secondary circuit conductors from a transformer to be protected by overcurrent devices in the primary circuit conductors only in two special cases: a transformer with a 2-wire primary and a 2-wire secondary; and a 3-phase, delta-delta-connected transformer having a 3-wire, single-voltage secondary. Either case requires transformer primary protection in accordance with 450.3. Where the primary feeder to the transformer incorporates OCPD rated (or set) at a level not to exceed those prescribed herein, it is not necessary to duplicate them at the transformer.

Requirements for the overcurrent protection of transformer conductors are found in 240.4(F) and 240.21(B). Also, Article 240, Part VIII and Part IX contain overcurrent protection requirements for feeders and feeder taps associated with transformers.

Informational Note No. 2: Nonlinear loads can increase heat in a transformer without operating its overcurrent protective device.

The increased heating effects of nonlinear load currents must be taken into account when determining the load on a transformer. Methods for handling these heating effects include derating equipment, oversizing equipment, increasing insulation ratings, installing thermal protection systems, and using K-factor transformers. The optimum method for dealing with transformer overheating varies, depending on several technical and economic factors, and is best determined during the design phase of the electrical system.

(A) Transformers Over 1000 Volts, Nominal. Overcurrent protection shall be provided in accordance with Table 450.3(A).

Unlike the information contained in informational notes, which are explanatory in nature and not enforceable, table notes are part of the requirements of the table.

TABLE 450.3(A) *Maximum Rating or Setting of Overcurrent Protection for Transformers Over 1000 Volts (as a Percentage of Transformer-Rated Current)*

		Primary Protection over 1000 Volts		Secondary Protection (See Note 2.)		
				Over 1000 Volts		1000 Volts or Less
Location Limitations	**Transformer Rated Impedance**	**Circuit Breaker (See Note 4.)**	**Fuse Rating**	**Circuit Breaker (See Note 4.)**	**Fuse Rating**	**Circuit Breaker or Fuse Rating**
Any location	Not more than 6%	600% (See Note 1.)	300% (See Note 1.)	300% (See Note 1.)	250% (See Note 1.)	125% (See Note 1.)
	More than 6% and not more than 10%	400% (See Note 1.)	300% (See Note 1.)	250% (See Note 1.)	225% (See Note 1.)	125% (See Note 1.)
Supervised locations only (See Note 3.)	Any	300% (See Note 1.)	250% (See Note 1.)	Not required	Not required	Not required
	Not more than 6%	600%	300%	300% (See Note 5.)	250% (See Note 5.)	250% (See Note 5.)
	More than 6% and not more than 10%	400%	300%	250% (See Note 5.)	225% (See Note 5.)	250% (See Note 5.)

Notes:

1. Where the required fuse rating or circuit breaker setting does not correspond to a standard rating or setting, a higher rating or setting that does not exceed the following shall be permitted:
   a. The next higher standard rating or setting for fuses and circuit breakers 1000 volts and below, or
   b. The next higher commercially available rating or setting for fuses and circuit breakers above 1000 volts.
2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than six circuit breakers or six sets of fuses grouped in one location. Where multiple overcurrent devices are utilized, the total of all the device ratings shall not exceed the allowed value of a single overcurrent device. If both circuit breakers and fuses are used as the overcurrent device, the total of the device ratings shall not exceed that allowed for fuses.
3. A supervised location is a location where conditions of maintenance and supervision ensure that only qualified persons monitor and service the transformer installation.
4. Electronically actuated fuses that may be set to open at a specific current shall be set in accordance with settings for circuit breakers.
5. A transformer equipped with a coordinated thermal overload protection by the manufacturer shall be permitted to have separate secondary protection omitted.

For Note 1 of Table 450.3(A), concerning standard ratings of circuit breakers and fuses, see 240.6. For Note 2, overcurrent protection of the secondary of a transformer is allowed to consist of not more than six sets of fuses or six circuit breakers. For Note 3, equipment maintenance is performed by personnel who have received safety training and are familiar with proper operation of the equipment and aware of the hazards associated with it. See Article 100 for the definition of a *qualified person*.

For Note 4, an *electronically actuated fuse* responds to a signal from an electronic control rather than heat from a current. See the definition in Article 100, Part II.

Exhibits 450.1 and 450.2 illustrate the conditions given in Note 2, which also appears in Table 450.3(B) for transformers rated 1000 volts and less.

The ratings or settings obtained from Table 450.3(A) are based on the type of protective device (fuse, electronic fuse, or circuit breaker), transformer-rated current and impedance, and primary and secondary voltages. The maximum ratings or settings of an OCPD for transformers rated over 1000 volts are separated into two broad categories: *any location* (or unsupervised) and *supervised locations only*.

The first category is not limited by location and is referred to as *any location*. The maximum ratings or settings for overcurrent devices permitted are applicable to all unsupervised locations. An *any location* transformer installation must be provided with overcurrent protection in both the primary and secondary circuit. See Exhibit 450.3 for an example of an installation using circuit breakers on the primary and the secondary for an over 1000-volt transformer with 6-percent impedance.

The second category for over 1000-volt transformers is *supervised locations only*. The maximum ratings or settings for overcurrent devices permitted are strictly limited to the supervised location conditions explained in Note 3. The installation shown in

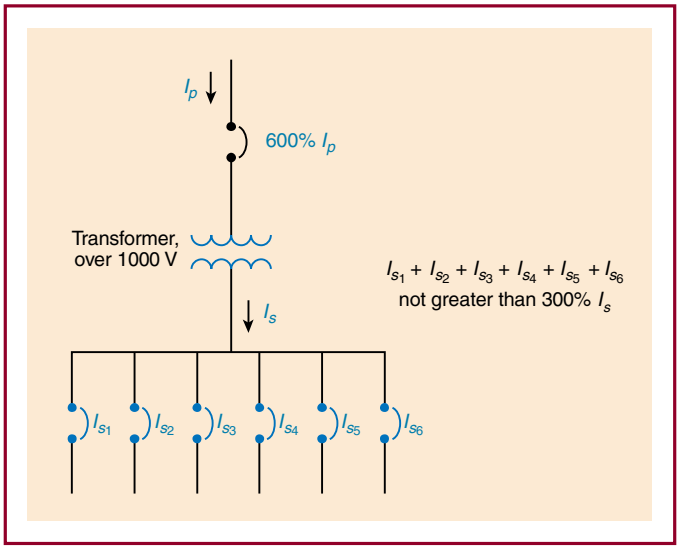

EXHIBIT 450.1 *A transformer rated over 1000 volts with a secondary rated over 1000 volts, with secondary protection consisting of six circuit breakers. The sum of the ratings of the circuit breakers is not permitted to exceed 300 percent of the rated secondary current.*

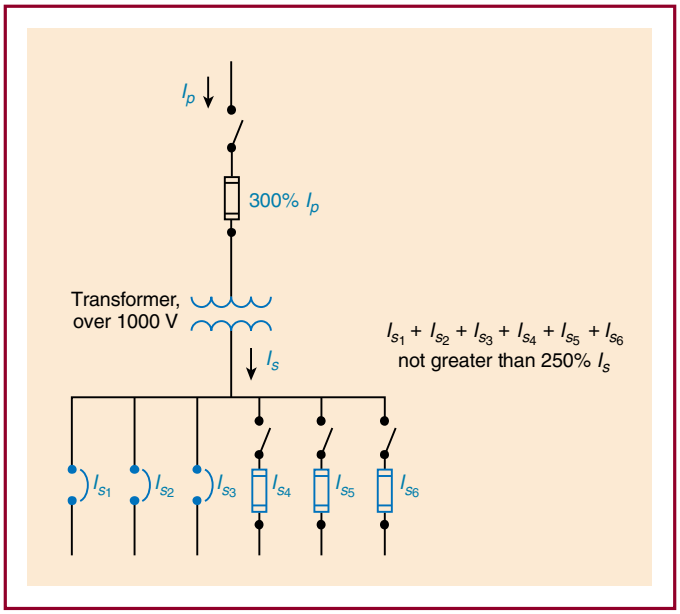

EXHIBIT 450.2 *A transformer rated over 1000 volts with a secondary rated over 1000 volts, with secondary protection consisting of fuses and circuit breakers. The sum of the ratings of all the overcurrent devices is not permitted to exceed the rating permitted for fuses.*

Exhibit 450.3 fulfills the requirements of both *any location* and *supervised locations only*.

See the commentary following 450.3 regarding the protection of transformer primary and secondary conductors.

(B) Transformers 1000 Volts, Nominal, or Less. Overcurrent protection shall be provided in accordance with Table 450.3(B).

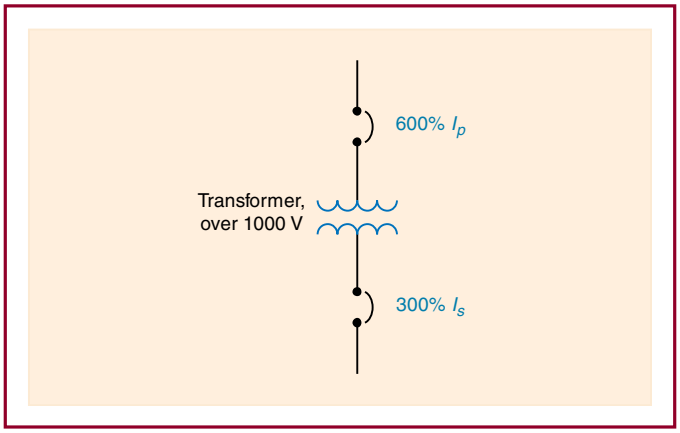

EXHIBIT 450.3 *A transformer with 6-percent impedance and rated over 1000 volts using circuit-breaker protection for both the primary and the secondary. Both the primary and the secondary voltages are over 1000 volts.*

The ratings or settings of the OCPD obtained from Table 450.3(B) are based on the transformer-rated current and whether secondary protection is provided. According to Table 450.3(B), the maximum ratings or settings of OCPDs for transformers rated 1000 volts and less are separated into two categories: *primary only protection* and *primary and secondary protection*.

Transformers must be protected by either of two methods. Method 1 requires primary protection only. Method 2 requires secondary side overcurrent protection at not more than 125 or 167 percent (depending on secondary current rating), provided the primary side overcurrent protection is not more than 250 percent of the primary side current rating.

An example of *primary only protection* is shown in Exhibit 450.4. An example of *primary and secondary protection* is shown in Exhibit 450.5. For overcurrent protection of motor control circuit transformers, see 430.72(C).

See the commentary following 450.3 regarding the protection of transformer primary and secondary conductors.

Exception: Where the transformer is installed as a motor control circuit transformer in accordance with 430.72(C)(1) through (C)(5).

(C) Voltage (Potential) Transformers. Voltage (potential) transformers installed indoors or enclosed shall be protected with primary fuses.

Informational Note: For protection of instrument circuits including voltage transformers, see 408.52.

450.4 Autotransformers 1000 Volts, Nominal, or Less

(A) Overcurrent Protection. Each autotransformer 1000 volts, nominal, or less shall be protected by an individual overcurrent device installed in series with each ungrounded input conductor. Such overcurrent device shall be rated or set at not more than 125 percent of the rated full-load input current of the autotransformer. Where this calculation does not correspond to a standard

TABLE 450.3(B) *Maximum Rating or Setting of Overcurrent Protection for Transformers 1000 Volts and Less (as a Percentage of Transformer-Rated Current)*

	Primary Protection			Secondary Protection (See Note 2.)	
Protection Method	**Currents of 9 Amperes or More**	**Currents Less Than 9 Amperes**	**Currents Less Than 2 Amperes**	**Currents of 9 Amperes or More**	**Currents Less Than 9 Amperes**
Primary only protection	125% (See Note 1.)	167%	300%	Not required	Not required
Primary and secondary protection	250% (See Note 3.)	250% (See Note 3.)	250% (See Note 3.)	125% (See Note 1.)	167%

Notes:

1. Where 125 percent of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, a higher rating that does not exceed the next higher standard rating shall be permitted.
2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than six circuit breakers or six sets of fuses grouped in one location. Where multiple overcurrent devices are utilized, the total of all the device ratings shall not exceed the allowed value of a single overcurrent device.
3. A transformer equipped with coordinated thermal overload protection by the manufacturer and arranged to interrupt the primary current shall be permitted to have primary overcurrent protection rated or set at a current value that is not more than six times the rated current of the transformer for transformers having not more than 6 percent impedance and not more than four times the rated current of the transformer for transformers having more than 6 percent but not more than 10 percent impedance.

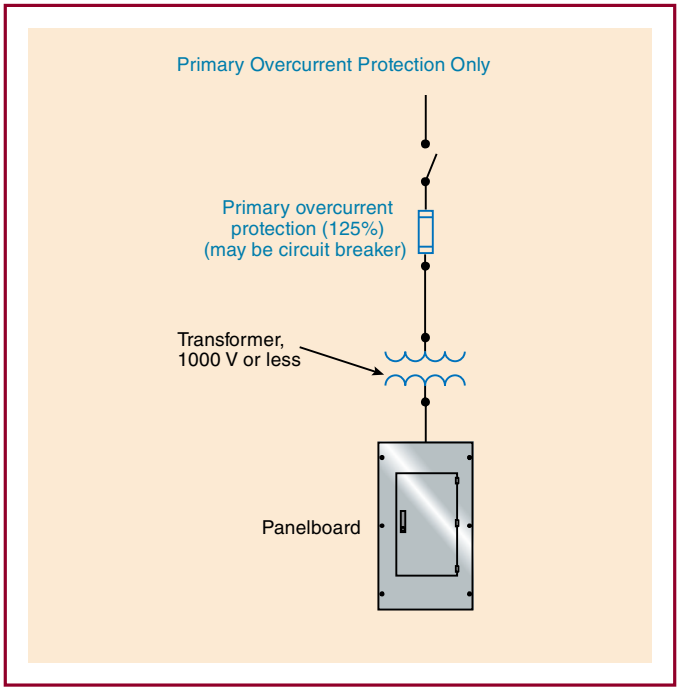

EXHIBIT 450.4 *A transformer (with currents of 9 amperes or more) rated 1000 volts or less with only primary overcurrent protection.*

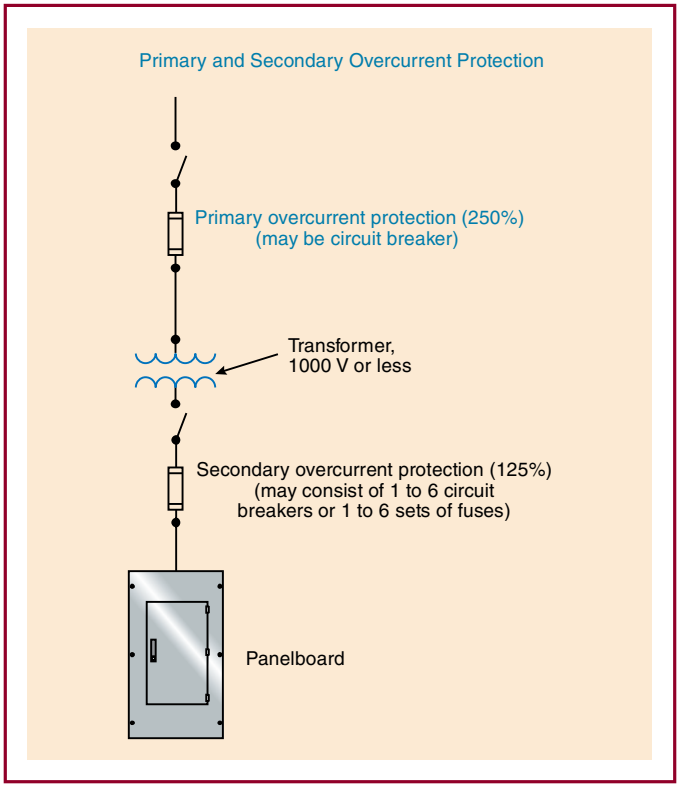

EXHIBIT 450.5 *A transformer (9 amperes or more) rated 1000 volts or less and protected by a combination of primary and secondary overcurrent protection.*

ARTICLE 450 Transformers and Transformer Vaults

introduction

This Article contains requirements for the installation of all transformers.

101 450.3 Overcurrent Protection

Overcurrent protection of the primary winding of a transformer not exceeding 600V must comply with (B).

FPN 2: 4-wire three-phase 120/208V or 277/480V systems that supply nonlinear line-to-neutral loads can overheat because of triplen harmonic currents (3rd, 9th, 15th, 21st, etc.) [450.9 FPN 2]. Figure 450–2

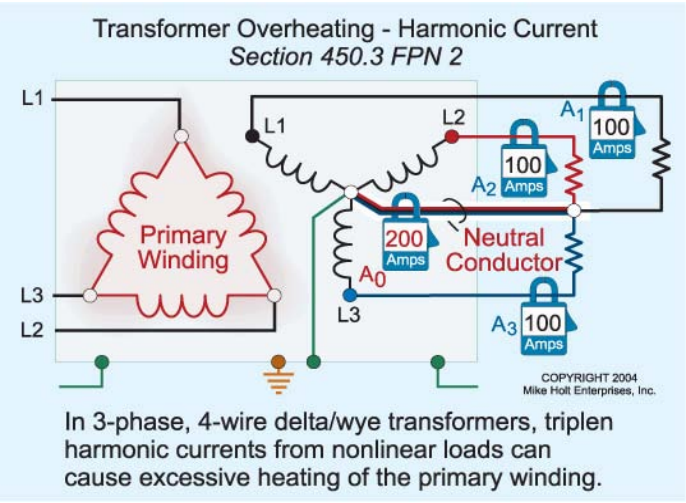

Figure 450–2

AUTHOR'S COMMENT: For more information on this subject, visit www.NECCode.com.

(B) Overcurrent Protection for Transformers Not Over 600V. The primary winding of a transformer must be protected against overcurrent in accordance with the percentages listed in Table 450.3(B) and all applicable notes.

Table 450.3(B) Primary Protection only

Primary Current Rating	Maximum Protection
9A or More	125%, see Note 1
Less Than 9A	167%
Less Than 2A	300%

Note 1. Where 125 percent of the primary current doesn't correspond to a standard rating of a fuse or nonadjustable circuit breaker, the next higher rating is permitted [240.6(A)].

Question: *What is the primary protection device rating and conductor size required for a 45 kVA, three-phase, 480V—120/208V transformer that is fully loaded? Terminals are rated 75°C.* Figure 450–3

(a) 8 AWG, 40A *(b) 6 AWG, 50A*
(c) 6 AWG, 60A *(d) 4 AWG, 70A*

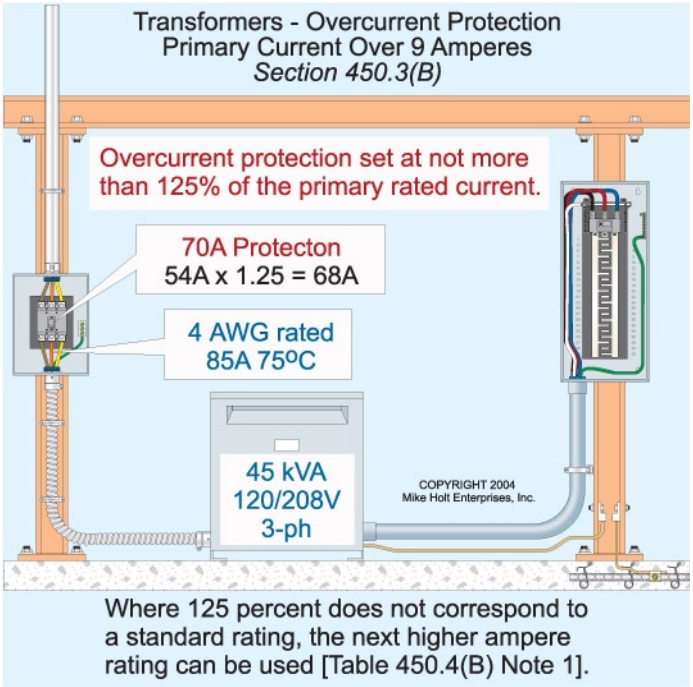

Figure 450–3

Answer: *(d) 70A*

Step 1: Primary current

I = VA/(E x 1.732)
I = 45,000 VA/(480V x 1.732)
I = 54A

Step 2: The primary protection device rating [240.6(A)]

54A x 1.25 = 68A, next size up 70A, Note 1

Step 3: The primary conductor must be sized to carry 54A continuously (54A x 1.25 = 68A) [215.2(A)(1)] and be protected by a 70A protection device [240.4(A)]. A 4 AWG conductor rated 85A at 75°C meets all of the requirements [110.14(C)(1) and 310.16].

Step 4: Secondary current

I = VA/(E x 1.732)
I = 45,000 VA/ (208V x 1.732), = 125A

AUTHOR'S COMMENT: Secondary conductors having a maximum length of 25 ft that terminate in an overcurrent protection device that doesn't exceed the ampacity of the conductors, must be sized at 125 percent of the continuous load [215.2(A)(1) and 240.21(C)(6)].

Question: *What is the secondary conductor size required for a 45 kVA, three-phase, 480V—120/208V transformer, that supplies a 200A lighting and appliance panelboard that is fully loaded? Terminals are rated 75°C.* Figure 450–4

(a) 1 AWG (b) 1/0 AWG (c) 2/0 AWG (d) 3/0 AWG

Answer: *(c) 2/0 AWG*

Step 1: Secondary current

I = VA/(E x 1.732)
I = 45,000 VA/(208V x 1.732)
I = 125A

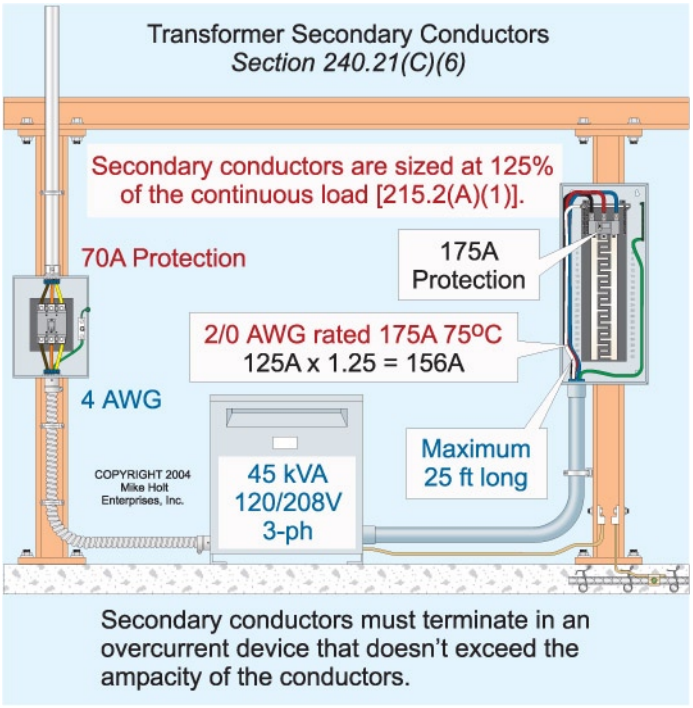

Figure 450–4

Step 2: Secondary conductors must be sized to 125 percent of the continuous load [215.2(A)(1)].

125A x 1.25 = 156A, 2/0 AWG rated 175A at 75°C termination

Secondary conductors must terminate in an overcurrent protection device that doesn't exceed the ampacity of the conductors [240.21(C)(6)]. 2/0 AWG, rated 175A at 75°C, terminating on a 175A protection device meets this requirement.