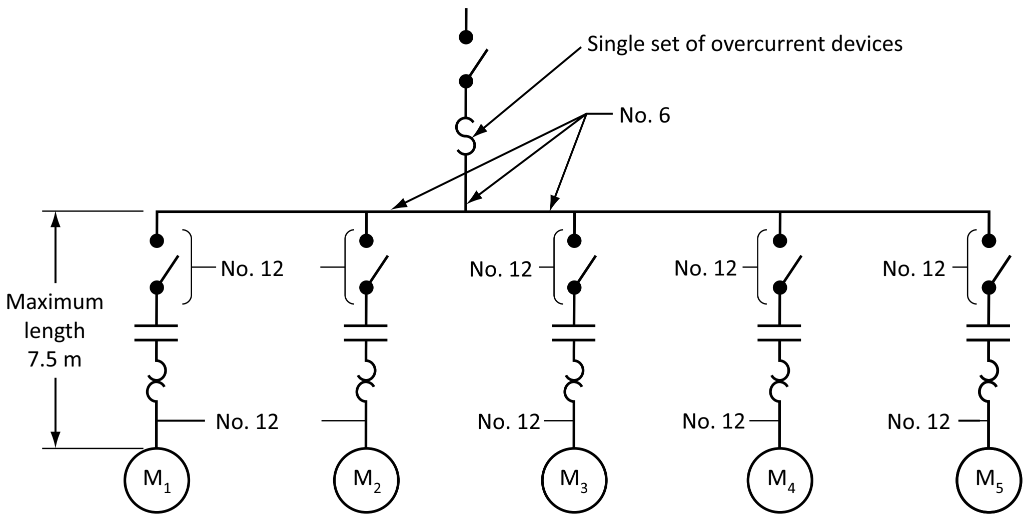
- have an ampacity equal to or greater than one-third of the ampacity of the branch circuit conductor; and
- are at least 7.5 m long.
(see Figure 28-9)

Figure 28-9
Tap conductors to more than one motor



No.	Duty service	FLC	Minimum branch circuit ampacity	Minimum conductor size (see Table 2)
M_1	Continuous	9	9 × 1.25 = 11.25	No. 14*
M_2	Continuous	12	12 × 1.25 = 15	No. 14*
M_3	Continuous	6	6 × 1.25 = 7.5	No. 14*
M_4	Non-continuous, short time, 30 minute rating	11	11 × 1.5 = 16.5	No. 12*
M_5	Non-continuous, varying, 15 minute rating	5	5 × 1.2 = 6	No. 14*

Minimum motor branch circuit conductor size = 2 or more motors
Minimum ampacity = (12 × 1.25) + 9 + 6 + 16.5 + 6 = 52.5 A [Rule 28-108 1) c)]
Minimum conductor size (in conduit) = No. 6* (Table 2)
Ampacity of a No. 6 in conduit = 55 A
Minimum individual motor branch circuit conductor amperes = 1/3 of 55 A = 18.3 A
Minimum individual motor branch circuit conductor size = No. 12
* *Since the motor's equipment does not have a marked conductor termination rating and the equipment is rated 100 A or less, Rule 4-006 2) a) requires that the 60 °C column of Table 2 be used.*

Rule 28-108 Insulated conductors — Two or more motors

The minimum ampacity of circuit conductors supplying a group of two or more motors is determined from the following criteria:

- the FLC of each motor;
- whether each motor is used for continuous or non-continuous duty service;

- for non-continuous duty service motors, the calculated currents of each motor; and
- the number of motors that are in operation at the same time.

In Subrule 1) a), the minimum required ampacity of the circuit conductor where there are two or more continuous duty service motors, is calculated by adding together:
- 125% of the largest motor's full load current (1.25 × FLC) plus;
- the sum of the remaining full load currents of motors that are operating at the same time.

We do not add together 125% of the sum of all full load currents, because it is assumed that all motors do not start simultaneously. In the event of simultaneous starting, the starting inrush current, which persists for only a short duration, would not cause significant or adverse heating of the conductors.

In Subrule 1) b), the minimum required ampacity of the circuit conductor, where there are two or more non-continuous duty service motors, is calculated by adding together the calculated currents for all the non-continuous duty service motors that are in operation at the same time. These currents are calculated using Rule 28-106 2).

In Subrule 1) c), the minimum ampacity of the circuit conductor (where there are both continuous and non-continuous duty service motors) is calculated by adding 125% of the FLC for the largest continuous duty motor to the sum of FLCs of the remaining continuous duty service motors that are operating at the same time. Lastly, we then add the sum of the calculated currents for all of the non-continuous duty service motors that are operating at the same time. These currents are calculated using Rule 28-106 2).

Subrule 2) allows the size of the circuit conductors supplying a group of motors to be reduced when the motors' control circuits are interlocked in a way that prevents all motors in the group from operating at the same time. The intention is to allow the ampacity of the circuit conductor feeding the group of motors to be determined by the subgroup of motors having the largest rating when operating at the same time.

Subrule 3) allows the application of demand factors based on load diversity (i.e., the specific characteristics of the motor loading by the motors connected to the circuit conductors), to allow a more realistic sizing of the conductor. An example of load diversity is the switching of motors or motor loading that occurs on a circuit during a manufacturing process. In situations like this, a lower feeder ampacity presents no reduction in safety because of the following provisions:
- Rule 28-204 4) requires that the feeder's protective devices do not have a higher rating than the circuit conductor (feeder) ampacity; and
- the circuit conductors need to be sized only for the maximum demand that can be placed upon them.

When the conductor size is reduced in accordance with Subrule 3), the overcurrent protection cannot be greater than that required by Rule 28-204 4).

Rule 28-110 Feeder conductors

Feeder conductors are the conductors that are found between the overcurrent device at the source of supply and the branch circuit overcurrent device or devices (e.g, panelboards or motor control centres).

Feeder conductors must have an ampacity high enough to supply motor loads without exceeding the temperature rating of the conductors' insulation and termination points. See Tables 28-2 and 28-3.

Subrule 1) requires that feeders supplying both motor loads and other types of loads are sized by adding the sum of the other types of loads directly to
- the minimum ampacity of the branch circuit conductor, where a single motor is connected (see Rule 28-106); or
- the minimum ampacity of the circuit conductor, where two or more motors are connected (see Rule 28-108).

Table 28-2
Method used to determine the feeder's minimum insulated conductor size for motors and non-motor loads

Step	Method
1	Determine the motor's contribution to the feeder for: • an individual continuous duty motor; • an individual non-continuous duty motor; • two or more continuous duty motors; • two or more non-continuous duty motors; or • a combination of continuous duty motors and non-continuous duty motors. See Rules 28-106 and 28-108.
2	Using the appropriate Sections and their Rules, determine the total contribution of any other non-motor loads to the feeder's minimum ampacity.
3	Calculate the minimum ampacity of the feeder conductor by adding the motor's and/or motor-compressor's minimum ampacity contribution (Step 1) to the total calculated minimum ampacity of the other non-motor loads (Step 2).
4	Determine the minimum size of the feeder conductor using the minimum ampacity rating calculated in Step 3 and the appropriate ampacity Table from the Code based on the wiring method being used.

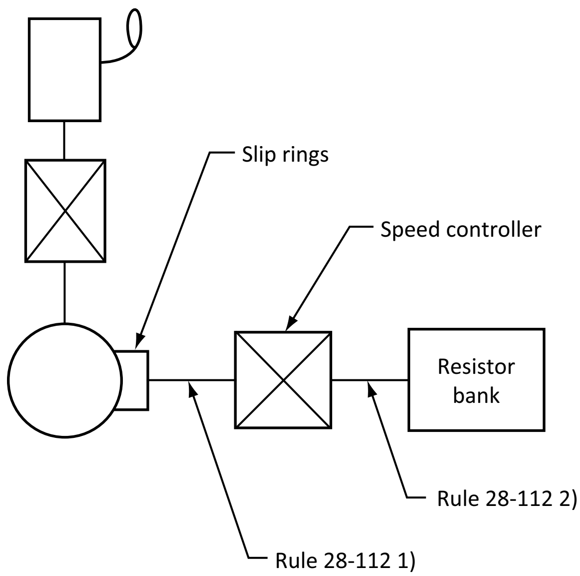
When a tap conductor is used from a feeder to a single set of overcurrent devices that protect a motor circuit only, Subrule 2) sets out requirements for the unprotected tap conductor. See the quick reference chart in Table 28-3.

Table 28-3
Method used to determine the tap conductor's minimum ampacity from a feeder to a single set of overcurrent devices protecting the motor's branch circuit insulated conductor

Type of tap conductor	Calculation of ampacity	Code reference
Tap conductors for motor circuits		
Tap conductors over 7.5 m in length	The same ampacity as the feeder conductor	Rule 28-110 2)
Tap conductors that are 3 m or less in length and that are enclosed in metal	When the tap conductor feeds a single continuous duty service motor: FLC × 1.25	Rules 28-106 1) and 28-110 2)
	When the tap conductor feeds more than one continuous duty service motor: FLC of the largest motor × 1.25, plus the combined FLCs of the remaining motors in operation at the same time	Rules 28-108 1) and 28-110 2)
Tap conductors that are 7.5 m or less in length and that are not enclosed in metal	Tap conductor amps = feeder conductor amps divided by 3	Rule 28-110 2) b)

Rule 28-112 Secondary insulated conductors
A wound rotor induction motor is a variable-speed ac motor that operates on the same principles as the squirrel-cage motor, but it differs somewhat in its construction. The rotor in a squirrel-cage motor is made up of shorted bars, while the rotor in a wound rotor motor consists of windings that terminate at slip rings on the motor shaft. This allows the speed of the motor to be varied. The slip rings connect the rotor windings to an external resistor bank. By varying the resistance, the motor's torque-speed characteristics can be changed. In a wound rotor motor operating at full speed, the external resistance is shorted out, and the motor works in the same way as a typical squirrel-cage motor. The branch circuit conductors for a wound rotor motor are sized using the same method as for squirrel-cage motors. See Figure 28-10.

Figure 28-10
Wound rotor motor — Branch circuit and secondary conductors



For a continuous duty service motor, Subrule 1) a) requires that the minimum ampacity of the conductors supplying the secondaries (the resistor bank) of a wound rotor motor are determined by multiplying the full load current of the secondary by 1.25. Subrule 1) b) requires that, for a non-continuous duty service motor, the percentage of the rated full load current, as specified on the nameplate [or specified in Table 27 using the motor's service classification (i.e., short-time, intermittent, periodic, or varying) and the motor's time rating, specified on the nameplate], is multiplied by the secondary current to determine the minimum size of the secondary conductor.

Secondary conductors are those that connect the slip rings in a wound rotor motor to the external resistance bank. Their minimum ampacity is a percentage of the secondary circuit's full load current, as determined by the duty classification of the external resistor bank set out in Table 28.

Overcurrent protection

The purpose of overcurrent protection is to de-energize a circuit, cutting off the electrical supply when the connected load causes more current to flow in the circuit than the intended design (sometimes referred to as "excessive current"). Overcurrent protection also de-energizes a circuit when the connected load has been shorted out or bypassed, leaving only the small resistance/impedance of the conductive path that is short-circuiting the load. This condition causes a large and virtually unimpeded current flow that can cause extensive damage to an electrical installation and cause a fire to start.

Motors impose special demands on circuits, and overcurrent protection has to be designed accordingly. During motor starting, the inrush current is approximately six times the motor's full load current. This initial inrush current lasts for a short time. However overcurrent protection devices will frequently respond to the inrush current as if it were a short and consequently de-energize the circuit. This is referred to in industry as "nuisance tripping". As a remedial solution for preventing motors from causing nuisance tripping when starting, the Code allows overcurrent devices to be sized with a current rating larger than the ampacity rating of the circuit conductors or the connected equipment. Short-circuit protection is still achieved when the overcurrent device is rated at a maximum of 300% of the conductors' or equipment's ampacity rating. The drawback though, is that oversized overcurrent devices no longer provide protection against the excessive current caused by an overload event. Overload and overheating protection for motors must be separately implemented as established in Rules 28-300 to 28-318.

Rule 28-200 Branch circuit overcurrent protection

Rule 28-200 requires that each ungrounded or *live* conductor of a branch circuit supplying a single motor is protected from short-circuit faults by a standard-rated overcurrent device (i.e., a fuse or circuit breaker), and that the maximum rating of the overcurrent protection is a percentage of the single motor's full load current. The rating varies according to

- the type of overcurrent device;
- whether the system is ac or dc;
- the number of phases;
- the type of starting; and
- the type of motor (as shown in Table 29).

The method in Table 28-4 is to be used to determine the maximum rating of an overcurrent device for individual motors. Table D16 may also be used.

Table 28-4
Method to determine the maximum overcurrent device size for an individual motor (other than a refrigerant motor-compressor)

Step	Method
1	Determine the motor's full load current (FLC).
2	Determine the type of overcurrent device used to protect the motor.
3	**DC motors** For a dc motor not protected by an instantaneous-trip (magnetic type) circuit breaker: • In Row 6 of Table 29, find the demand factor for the motor's FLC based on the type of overcurrent device selected in Step 2. • Using the FLC determined in Step 1, calculate the maximum overcurrent device size. • Using the overcurrent device's manufacturer's tables, select the maximum standard rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size. For a dc motor using an instantaneous-trip (magnetic type) circuit breaker: • for a dc motor rated 50 hp or less, multiply the FLC by 2.5 (250%); and • for a dc motor over 50 hp, multiply the FLC by 2.0 (200%).
4	**AC-single/1-phase motors** Determine whether the ac motor is 1-phase or 3-phase. For all types of 1-phase ac motors not protected by an instantaneous-trip (magnetic type) circuit breaker: • In Row 1 of Table 29, find the demand factor for the motor's FLC based on the type of overcurrent device selected in Step 2.

(Continued)

Table 28-4 (Continued)

Step	Method
	• Using the FLC determined in Step 1, calculate the maximum overcurrent device size. • Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size. For 1-phase ac motors using an instantaneous-trip (magnetic type) circuit breaker determine the maximum setting by multiplying: • the FLC by 13.0 (1300%); or • the locked rotor current (LRC) by 2.15 (215%).
5	**3-phase wound rotor motors** For 3-phase wound rotor motors not protected by an instantaneous-trip (magnetic type) circuit breaker: • In Row 5 of Table 29, find the demand factor for the motor's FLC based on the type of overcurrent device selected in Step 2. • Using the FLC determined in Step 1, calculate the maximum overcurrent device size. • Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size.
6	**3-phase squirrel cage motors** **3-phase resistor & reactor motors** **3-phase synchronous motors** For 3-phase ac motors using full-voltage (across-the-line) and resistor reactor starters or controllers and not protected by an instantaneous-trip (magnetic type) circuit breaker: • In Row 2 of Table 29, find the demand factor for the motor's FLC based on the type of overcurrent device selected in Step 2. • Using the FLC determined in Step 1, calculate the maximum overcurrent device size. • Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size. For 3-phase ac motors using an instantaneous-trip (magnetic type) circuit breaker determine the maximum setting by multiplying: • the FLC by 13.0 (1300%); or • the locked rotor current (LRC) by 2.15 (215%).
7	**Autotransformer and star-delta starters & controllers** **30 A or less** For 3-phase squirrel-cage and synchronous motors using autotransformer or star-delta starters or controllers, determine if the FLC is over 30 A. If the FLC is over 30 A, go to Step 8. For 3-phase ac motors using autotransformer or star-delta starters or controllers with a FLC not more than 30 A and not being protected by an instantaneous-trip (magnetic type) circuit breaker: • In Row 3 of Table 29, find the demand factor for the motor's FLC based on the type of overcurrent device selected in Step 2. • Using the FLC determined in Step 1, calculate the maximum overcurrent device size. • Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size.

(Continued)

Table 28-4 (Concluded)

Step	Method
	For 3-phase ac motors using an instantaneous-trip (magnetic type) circuit breaker determine the maximum setting by multiplying: • the FLC by 13.0 (1300%); or • the locked rotor current (LRC) by 2.15 (215%).
8	**Autotransformer and star-delta starters & controllers** **FLC over 30 A** This Step is for 3-phase squirrel-cage and synchronous motors using autotransformer and star-delta starters or controllers with a FLC over 30 A. For 3-phase ac motors using autotransformer and star-delta starters or controllers with a FLC over 30 A and not being protected by an instantaneous-trip (magnetic type) circuit breaker: • In Row 4 of Table 29, find the demand factor for the motor's FLC based on the type of overcurrent device selected in Step 2. • Using the FLC determined in Step 1, calculate the maximum overcurrent device size. • Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size. For 3-phase ac motors using an instantaneous-trip (magnetic type) circuit breaker determine the maximum setting by multiplying: • the FLC by 13.0 (1300%); or • the locked rotor current (LRC) by 2.15 (215%).
9	In some situations, even when overcurrent devices are sized in accordance with requirements of Subrule 3) and Table 29, the specific application, environment, types of load, or electrical system can still lead to nuisance tripping during starting, with the overcurrent device responding to the inrush current as a fault. In such cases, Subrule 4) allows the rating of the overcurrent protection to be increased. The Subrule specifies the multiplier, which vary depending on the type of overcurrent protection, that may be applied to the motor's full load current to arrive at an acceptable rating.

Subrule 2) d) stipulates that where instantaneous-trip circuit breakers use a magnetic trip only (i.e., no thermal unit), the requirements of Rule 28-210 must be used to size the maximum branch circuit overcurrent protection.

Subrule 2) e) allows the use of self-protected combination motor controllers for providing motor branch circuit overcurrent protection, if they comply with the requirements of Rule 28-500. In CSA C22.2 No. 14, a motor controller that has non-replaceable or integral discriminating overload and short-circuit current sensors, and is provided with one or more sets of contacts where the contacts cannot be isolated for separate testing, is considered to be a self-protected combination motor controller Type E. A controller comprised of a magnetic or solid-state motor controller coupled with a Type E controller is considered to be a self-protected combination motor controller Type F. If individual components can be shipped separately, the self-protected combination motor controller is required to be additionally marked "COMBINATION MOTOR CONTROLLER WHEN USED WITH…" or "SELF - PROTECTED COMBINATION MOTOR CONTROLLER WHEN USED WITH…". Line side terminal components may also be required in order to fulfill the terms of certification. Due to their integral construction, self-protected combination motor controllers are selected primarily on the basis of the overload protection requirements for the circuit.

In situations where the maximum overcurrent device size, calculated based on the individual motor's full load current and the demand factor of Table 29, is less than 15 A, Subrule 3) a) allows the overcurrent protection to be rated at 15 A.

Subrule 3) b) requires that the maximum rating of an overcurrent device protecting a branch circuit supplying two or more motors not exceed the values listed in Rule 28-206.

In some situations, even when overcurrent devices are over-sized in accordance with the requirements of Subrule 3) and Table 29, the specific application, environment, types of load, or electrical system can still lead to nuisance tripping during starting, with the overcurrent device responding to the inrush current as a fault. In such cases, Subrule 4) allows the rating of the overcurrent protection to be increased to a value that exceeds what Table 29 allows. Subrule 4) specifies the maximum rating or setting of the overcurrent protective device being used to protect the motor branch circuit. See the method in Table 28-6 and the sample calculations in Table 28-7.

Subrule 5) requires that where a thermal magnetic circuit breaker with separate instantaneous -trip settings is used as the overcurrent protection for a motor branch circuit, the rating of the breaker is not to exceed the values specified in Rule 28-210.

Rule 28-202 Overcurrent protection marked on equipment

There is motor control equipment available that is designed and constructed to have overcurrent tripping characteristics at settings that differ from the provisions shown in Table 29. In these cases, the requirements of this Rule apply.

Rule 28-204 Feeder overcurrent protection

Where a feeder circuit supplies branch circuits to motors, the overcurrent protection for the feeder is usually selected based on the assumption that the motors supplied by the feeder do not start simultaneously. The rating of the feeder's overcurrent device must be kept as low as possible to prevent overheating and subsequent fire hazards, but not so low that nuisance tripping occurs during motor starting.

Subrule 1) provides a method for determining the maximum rating of a feeder's overcurrent device based on the following:

- the type of overcurrent device used to protect the feeder [e.g., non-time-delay fuse, time delay fuse, inverse-time circuit breaker, or instantaneous trip (magnetic-type) circuit breaker];
- the highest calculated overcurrent device rating, determined in accordance with Rule 28-200, for a motor supplied by the feeder; and
- the full load current ratings of all other motors in operation at the same time connected on the feeder.

Note: *When one or more of the motors on the feeder is a refrigerant motor-compressor, the multiplier for determining the maximum calculated overcurrent protection rating for non-time-delay fuses, time-delay fuses, and inverse-time circuit breakers is the same. The multipliers are 50% of the LRC or the RLC × 6.0 × 0.5. The method is shown in Rule 28-708.*

Table 28-5
Method to determine the maximum standard overcurrent device for a group of two or more motors in operation on a feeder

Step	Method
1	Calculate the maximum calculated overcurrent device's rating for the type of overcurrent device used to protect the feeder for each motor that will be in operation on the feeder. **Note:** *When one or more of the motors on the feeder is a refrigerant motor-compressor, calculate the maximum calculated overcurrent protection using the method in Rule 28-708:* *Maximum calculated overcurrent protection = (RLC × 6.0 × 0.5) or (LRC × 0.5).*
2	Determine which calculated overcurrent device's rating is the largest for any motor in the group in Step 1 that will be in operation on the feeder.
3	Add the value of the largest calculated overcurrent device's rating from Step 2 to the sum of the FLC of all other motors that will be in operation on the feeder.
4	Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device size that is closest to, but does not exceed, the maximum rating from Step 3.

In installations where two or more motors are expected to start at the same time, a feeder overcurrent device selected in accordance with Subrule 1) may trip as a result of the combined starting inrush currents of the motors. This will prevent any motors on the feeder from starting.

For these situations, Subrule 2) provides a method for calculating an increased sizing of maximum overcurrent device, but limits the increase to not more than 300% of the ampacity rating of the feeder's conductors. This limitation will ensure that short circuit protection on the feeder conductors is not compromised.

The allowable increase is calculated by adding the full load currents of all the motors that start simultaneously and treating the total as the full load current of a single motor, whose starting surge is assumed to be equal to the sum of the starting surges of the individual motors. When determining which motors might start simultaneously, it is important to consider not just normal operating conditions, but also the conditions that exist after a sustained power interruption. The maximum allowable increase in the rating of the feeder overcurrent protection is based on the number of motors connected to the feeder that start simultaneously and on the type of overcurrent protection that is used to protect the feeder.

Table 28-6
Method to determine the maximum standard overcurrent device size for a feeder where simultaneously-starting motors trip the overcurrent device calculated from Rule 28-204 1)

Step	Method
1	Determine the FLC of all motors that will be in operation on the feeder that are required to start simultaneously.
2	Add together the FLCs of all the motors that are to start simultaneously.
3	Determine the FLC of each motor that will be in operation on the feeder but will not be starting simultaneously with any other motor.

(Continued)

Table 28-6 (Concluded)

Step	Method
4	Calculate the maximum calculated overcurrent device's rating for the type of overcurrent device used to protect the feeder for each motor in Steps 2 and 3.
5	Determine the largest calculated overcurrent device rating for any motor of the group in Step 1 that will be in operation on the feeder.
6	Add the value of the largest calculated overcurrent device rating from Step 5 to the sum of the FLCs of all other motors from Steps 2 and 3 that will be in operation on the feeder.
7	Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device size that is closest to, but does not exceed, the maximum rating from Step 6. **Note:** *This value cannot exceed 300% of the ampacity of the feeder conductor.*

Table 28-7
Sample calculations for determining minimum conductor size and maximum overcurrent protection (OCP) for ac squirrel-cage and dc motors

Horse-power rating	Voltage rating	Number of phases	Type of overcur-rent device	Full load current, A	Type of starting	Maximum overcur-rent rating	Standard rating for overcur-rent device, A	Calcula-tion of OCP size when the standard rating will not permit the motor to start - see Rule 28-200 4)	Standard rating for larger overcur-rent device, A
3/4	120	1	Non-time-delay fuse	13.8	Full-voltage	13.8 × 3 = 41.4	40	13.8 × 4 = 55.2	50
3	240	1	Time-delay fuse	17	Full-voltage	17 × 1.75 = 29.8	30	17 × 2.25 = 38.25	35
7.5	208	3	Circuit breaker	22 + 2.2 = 24.2	Full-voltage	24.2 × 2.5 = 60.5	60	24.2 × 4 = 96.8	90
15	600	3	Circuit breaker	17	Full-voltage	17 × 2.5 = 42.5	40	17 × 4 = 68	60
7.5	120	dc	Time-delay fuse	58	Full-voltage	58 × 1.5 = 87	80	58 × 2.25 = 130.5	125
75	600	3	Non-time-delay fuse	77	Auto-transformer	77 × 2 = 154	150	77 × 4 = 308	225