Allen-Bradley

Applying More Than One ArmorStart Motor Controller in a Single Branch Circuit on Industrial Machinery

Bulletin Numbers 280, 281, 284, 290, 291

Introduction

In general multiple-motor branch circuits, installing a motor controller that is not Listed for group installation does not comply with the NEC® and NFPA® 79. Two product designations are permissible under the NEC:

- listed factory assembly
- separate assemblies listed for such use

Listed means that a third-party nationally recognized test laboratory, such as Underwriters Laboratory, Inc.® (UL®) has certified that the motor controller has met specific product safety standards.

Each ArmorStart® motor controller is Listed for group installation. This document explains how to use this Listing to apply the ArmorStart product family of motor controllers in multiple-motor branch circuits. See 280-WP001, Group Installation Listing for Drives and Contactor-based Motor Controllers White Paper, for details regarding group motor Listing.

Background

The NEC (*National Electrical Code*®) is NFPA 70. NFPA 79 is the *Electrical Standard for Industrial Machinery*®. The 2014 version of the NEC refers to NFPA 79 in the first informational note of Article 670.

Group installation means that a single set of fuses or a single circuit breaker protects a branch circuit that supplies two or more motors and their controllers. Both the NEC and NFPA 79 have rules for controller installation in these multiple-motor branch circuits. Both also have special rules for controllers that are not Listed for group installation and general rules for controllers that are.

The special rules for controllers that are not Listed for group installation restrict some variables. These restricting rules are found in NEC 430.53(A), 430.53(B), and 430.53(C)(2)(b) and NFPA 79 7.2.10.2, 7.2.10.3, and the 7.2.10.4(1) condition, which requires that the product not exceed the requirements of section 7.2.10.1. For example, for 480V motors, NEC 430.53(A) limits each FLA rating to 6 A, and individual overload protection conforms to NEC 430.32. These special cases are not discussed in this document.

This document addresses this **general** case: If a motor controller is Listed for group installation, the NEC and NFPA 79 permit the following:

1. Installing it in a branch circuit with other motors having any mix of horsepower ratings
2. Protecting all wiring and controllers with a single set of fuses or a single circuit breaker large enough to operate this mix of motors.

The rules for this general case are found in the NEC 430.53(C) and 450.53(D) and in NFPA 79 7.2.10.4 and 7.2.10.5.

Importance of a motor controller being Listed for group installation

For this general case, the following conclusions apply:

- Unless a motor controller is Listed for group installation, its Listing covers only individual motor circuit installation, and installing it in a general multiple-motor circuit does not comply with NEC and NFPA 79.
- This Listing is physically important because it verifies that the short-circuit current rating of the controller is valid with the larger fuses and circuit breakers necessary to operate the multiple-motor circuit.
- If a motor controller is not Listed for group installation, the installer must add fuses or a circuit breaker in the input circuit for each motor controller.
- Therefore, the group installation Listing is important because it verifies that the short-circuit current rating of the controller applies to the multiple-motor branch circuit and eliminates the requirement for the additional input circuit protective device(s).

From the perspective of the ArmorStart product family, being Listed for group installation means one set of fuses or one circuit breaker can protect a branch circuit that has two or more of these motor controllers that are connected to it. This document refers to this type of branch circuit as a multiple-motor branch circuit. The circuit topology that is shown in Figure 1, is one example of multiple possible configurations of a multiple-motor branch circuit. In these circuits, a single set of fuses (or a single circuit breaker) protects multiple motors, their controllers, and the circuit conductors. The motors can be any mixture of power ratings and the controllers can be any mixture of motor controller technologies, such as magnetic motor controllers and variable-frequency AC drive controllers.

This document addresses only NFPA 79 applications because industrial machinery is their primary market, not because these products are only suitable for industrial machinery. While all versions of the ArmorStart products can be applied on industrial machinery, the versions that have the Conduit Entrance Gland Plate option can also be used in applications governed by NFPA 70 (NEC), (see ArmorStart Product Family).

Listing requirements for "factory assembly" and "separate assemblies"

- The first sentence of NEC 430.53(C) relies on two terms that the NEC does not define: ""factory assembly" and "separate assemblies". The text also requires both to be "listed": "listed factory assembly" or "separate assemblies listed for such use". 45A of UL 508C, "*Power Conversion Equipment*", contains the 430.53(C) Listing requirements for drives. 52A of UL 508, "*Industrial Control Equipment*", contains the 430.53(C) Listing requirements for contactor-based motor controllers. Neither contains the term "factory assembly" or the term "separate assemblies" and each requires this marking: "Suitable for motor group installation…".
- Therefore, the terms "factory assembly" and "separate assemblies" do not change the Listing requirements. All drives and contactor-based motor controllers that are Listed for 430.53(C) installation are marked "Suitable for motor group installation…".

In the 2012 Edition of NFPA 79, motor controllers that are Listed for group installation can be installed in multiple-motor branch circuits according to either of two alternative sets of requirements. The first is found in 7.2.10.4(2), the second in 7.2.10.4(3). The requirements of 7.2.10.4(3) are similar to the requirements in NEC 430.53(C) while the requirements of 7.2.10.4(2) are found only in NFPA 79. This document explains the requirements of 7.2.10.4(2), rather than the requirements of 7.2.10.4(3), because it is the easier method to use when applying the ArmorStart family of motor controllers.

You must determine the requirements – NFPA 79 or NFPA 70 (NEC) – to use for the application. When making this determination, it is necessary to understand the ArmorStart product characteristics and useful to understand the definition of industrial machinery. TheArmorStart Product Family section of this document specifies whether a motor controller is suitable for installation according to NFPA 79, NEC, or both. The definition of industrial machinery is found in 3.3.56 of NFPA 79 and 670.2 of Article 670, Industrial Machinery, in the NEC.

Conventions

The following conventions are used throughout this document:

- Although all equipment is connected to a three-phase electrical supply, all figures are shown as one-line diagrams.
- Although all ArmorStart motor controllers are Listed for group installation with both fuses and a specific family of inverse time circuit breakers, this document considers only fuses.
  These conventions are used to avoid repetitive explanations with minor, but necessary, qualifications for circuit breakers. Generally, the principles for selecting the fuses also apply to selecting inverse time circuit breakers.
- All references, unless indicated otherwise, are to NFPA 79 – 2012.
- The examples in this document use an ArmorStart LT circuit to provide a more comprehensive demonstration, but the concepts that are demonstrated apply to the entire ArmorStart product family.

ArmorStart Product Family

This section contains a brief description of the attributes of the ArmorStart LT motor controllers that are relevant to applying them in multiple-motor branch circuits. These same relative attributes can be assumed for ArmorStart controllers.

The term motor controller refers to the device that stops and starts the motor. The ArmorStart product family consists of two types of motor controllers. The Bulletin 290 and 291 controllers are magnetic motor controllers that use an electromechanical contactor to stop and start the motor. The Bulletin 294 motor controllers use a variable-frequency AC drive to stop, start, and vary the speed of the motor. This document refers to the Bulletin 290, 291 and 294 products as either motor controllers or just controllers.

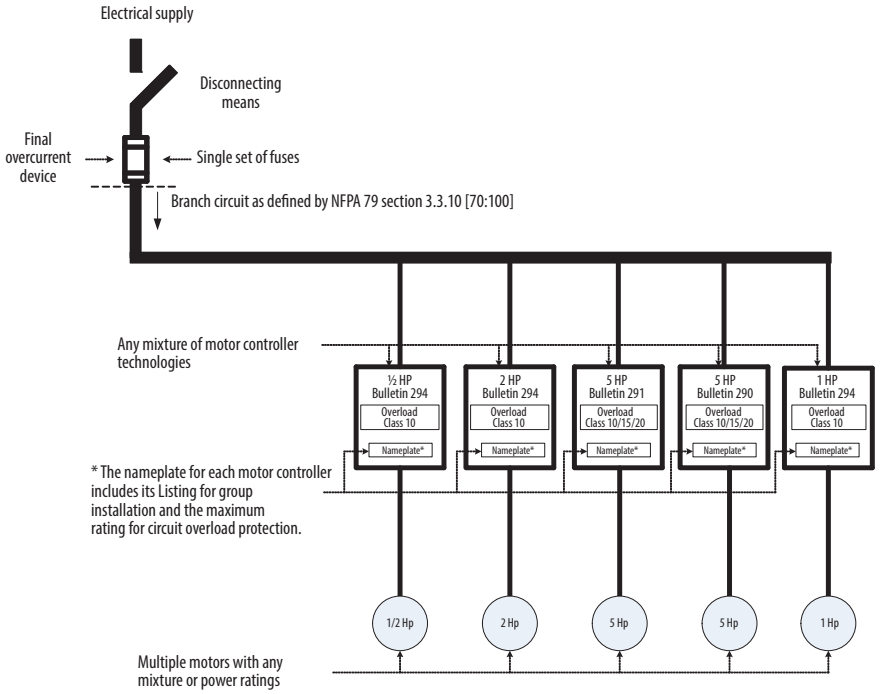
Each ArmorStart motor controller incorporates an integrated overload relay and motor disconnecting means. The Underwriters Laboratories Inc.® (UL®) Listing for each motor controller confirms that the motor controller, including its integral overload relay and motor disconnecting means, is suitable for motor group installation.

The suitability of each ArmorStart LT motor controller for installation according to either NFPA 79 or NEC depends on the means of connecting the power circuit wiring. All controllers are suitable for installation in multiple-motor branch circuits on industrial machinery according to 7.2.10.4 of NFPA 79. The controllers that have the Conduit Entrance Gland Plate option are also suitable for installation in multiple-motor branch circuits according to NEC 430.53(C) and 430.53(D). The controllers that have the Power Media Gland Plate option are suitable for installation only on industrial machinery. These versions are limited to industrial machinery because the UL Listing for the power media connectors themselves and their matching cable assemblies covers installation only on industrial machinery.

Multiple-motor Branch Circuits and Motor Controllers Listed for Group Installation – General Explanation

Multiple-motor branch circuits, like that shown in Figure 1, have this fundamental tradeoff: protecting more than one controller with a single set of fuses requires more electrical and mechanical robustness in each controller.

Figure 1 - ArmorStart LT NFPA 79 Multi-motor Branch Circuit

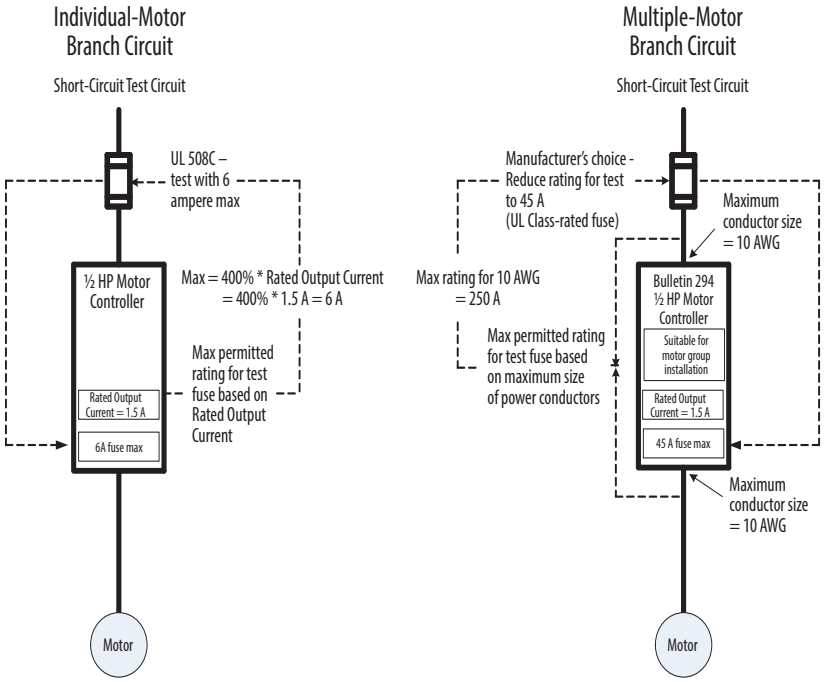


In exchange for eliminating the cost and space necessary for a dedicated set of fuses in front of each controller, the construction of each controller itself must be more robust. For the circuit configuration shown in Figure 1 to be practical, the ampere fuse rating must be large enough to operate all motors, without opening, under normal starting and running conditions. This fuse rating must be larger than the rating permitted to protect a circuit that supplies only a single motor and its controller. In general, as the fuse rating increases, so does the magnitude of fault currents that flow until the fuse opens. This higher magnitude of fault current results in more damage to the controller. Therefore, the additional controller robustness is necessary to withstand these higher fault currents without controller damage, which could result in a shock or fire hazard.

Consequently to the controller being Listed for group installation, mostly means that the UL testing is performed with fuses that have this practical, and higher, ampere rating. This testing verifies that it is safe to apply this controller in a multiple-motor branch circuit, provided the fuse is of the same class and does not have a rating exceeding that marked on the controller.

The example in Figure 2 illustrates this increase in the maximum ampere rating of a fuse that is permitted to protect a controller. This example compares the fuse rating that is used in the UL testing of two variable-frequency AC drive-based motor controllers. Both controllers have a rated power of 0.5 Hp and a rated output current of 1.5 A. The controller that is shown on the left is intended for installation in individual-motor branch circuits. The controller that is shown on the right is the ArmorStart LT Bulletin 294 controller that must be Listed for group installation to be installed, as intended, in multiple-motor branch circuits. For this example, assume that all testing is done with fuses of the same class.

Figure 2 - UL508C Variable-frequency AC Drive Motor Controller Evaluation



The UL investigation of both controllers is done according to UL 508C, *Power Conversion Equipment*. The controllers are connected to the test supply through the three-phase conductors and equipment grounding conductor and then covered with cotton in areas that are likely to vent hot gases and sparks during the tests. During the test, electrical faults are impressed on the output of, and internal to, these variable-frequency AC drive-based controllers. Increasing the ampere fuse ratings increases the magnitude of the fault currents that flow through, and damage, the controller before the fuses open. After the test, the damage to the controller is evaluated to determine whether a potential shock or fire hazard exists when it is protected by fuses with this ampere rating. One criterion of the evaluation is the examination of the equipment grounding conductor that must not open during the test, because this could leave exposed conductive parts in an energized state (shock hazard). Another criterion is that the cotton must not ignite, because this indicates the expulsion from the controller of hot gases or molten metal fragments (fire hazard).

Referring to the controller on the left, UL 508C permits the individual-motor testing to be performed with the maximum fuse rating that can be used to protect an individual-motor branch circuit. According to both the NEC and NFPA 79, this is 400 percent of the full-load current rating of the largest motor that the controller can supply. In UL 508C, this is taken to be 400 percent of the rated output current of the controller, or 6 A.

Referring to the controller on the right, UL 508C permits the group installation testing to be performed with the maximum fuse rating that can be used to protect a multiple-motor branch circuit. According to both NEC (430.53(C)) and NFPA 79 (7.2.10.4(3)), this is 250 A. This value, which is derived from the installation requirements of NEC 430.53(C) and 430.53(D), is determined by the largest size of power conductor that the ArmorStart LT controller can accept, 10 AWG. Because the UL 508C test covers all possibilities in the NEC and NFPA 79, it permits the maximum value of 250 A. This covers 7.2.10.4(2), which permits only 100 A. However in this case the manufacturer, Rockwell Automation, chose to test and mark with the lower value of 45 A. This value was chosen as the tradeoff between the maximum number and type of controllers in the branch circuit (limited by the maximum fuse rating and the standard let-through current under a fault condition) and the electrical and mechanical robustness that is engineered into each controller.

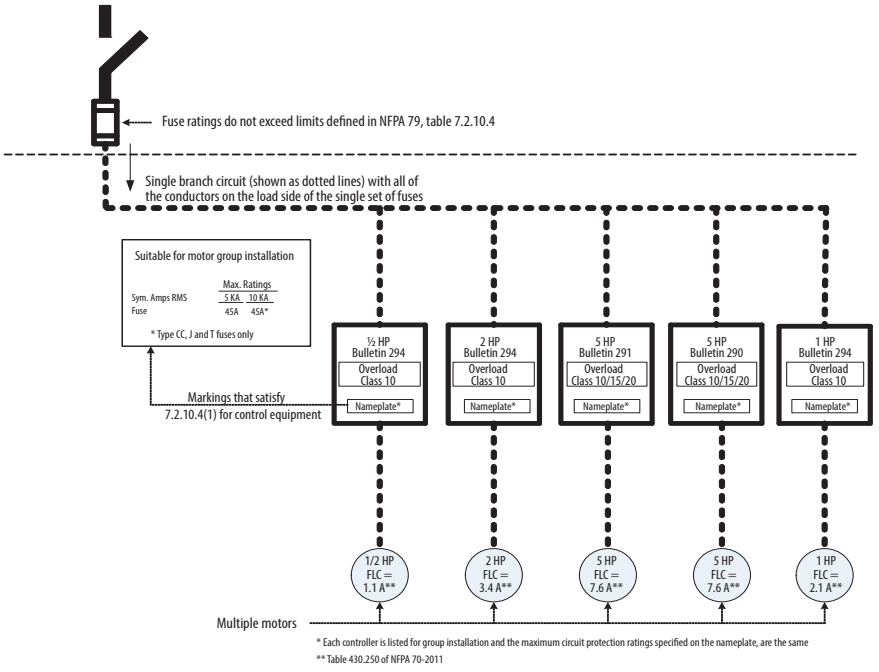
Therefore, to make its use in the multiple-motor branch circuit of Figure 1 practical, the 0.5 Hp, Bulletin 294 controller was engineered to be robust enough to safely contain the damage when protected by a fuse having a rating of 45 A, rather than just 6 A.

Maximum Fuse Ampere Rating according to 7.2.10.4(1) and 7.2.10.4(2)

This section uses Figure 3 to explain the requirements from 7.2.10.4(1) and 7.2.10.4(2) that are relevant to, and permit, the multiple-motor branch circuit of Figure 1, as long as the following is true:

1. All motor controllers are Listed for group installation.
2. The fuse does not exceed the maximum rating that NFPA 79, Table 7.2.10.4 permits to protect the smallest conductor.
3. The fuse complies with the maximum fuse ratings of all controllers.

Figure 3 - ArmorStart LT NFPA 79 Multi-motor Branch Circuit



Explanatory Example

The example addresses the overcurrent protection of the conductors, controllers, and motors. Protection for three overcurrent conditions is considered: motor running overloads, short-circuit (line-to-line) faults, and ground-faults (line-to-ground). The short-circuit fault and ground-fault protection are governed by 7.2.10.4(1) and 7.2.10.4(2) and explained in Requirements 1, 2, and 3 and Figure 4. The overload protection, explained in Requirement 4, is governed by 7.3.1 and 7.3.1.1. Overload coordination depends on each conductor having the minimum ampacity that is given by 12.5.3 and 12.5.4. The method for determining this minimum ampacity is explained in Requirement 5 and Figure 5.

The example branch circuit is shown in Figure 4 and Figure 5. The circuit topology consists of a set of 10 AWG conductors that supply multiple sets of 14 AWG conductors. Each set of 14 AWG conductors supply a controller and motor. These conductor sizes are chosen to be the smallest conductors that have sufficient ampacity, without derating, for the loads each must carry. All wiring is customer supplied, rather than the ArmorConnect® Power Media, because all controllers have the Conduit Entrance Gland Plate Option. Fuses protect the branch circuit.

The example addresses five basic requirements that the motor controllers, fuses, and conductors must satisfy. The letters in the circles on Figure 4 and Figure 5 are referenced in the explanations as letters in parentheses.

Figure 4 - ArmorStart LT NFPA 79 Multi-motor Branch Circuit — Conductor and Controller Protection

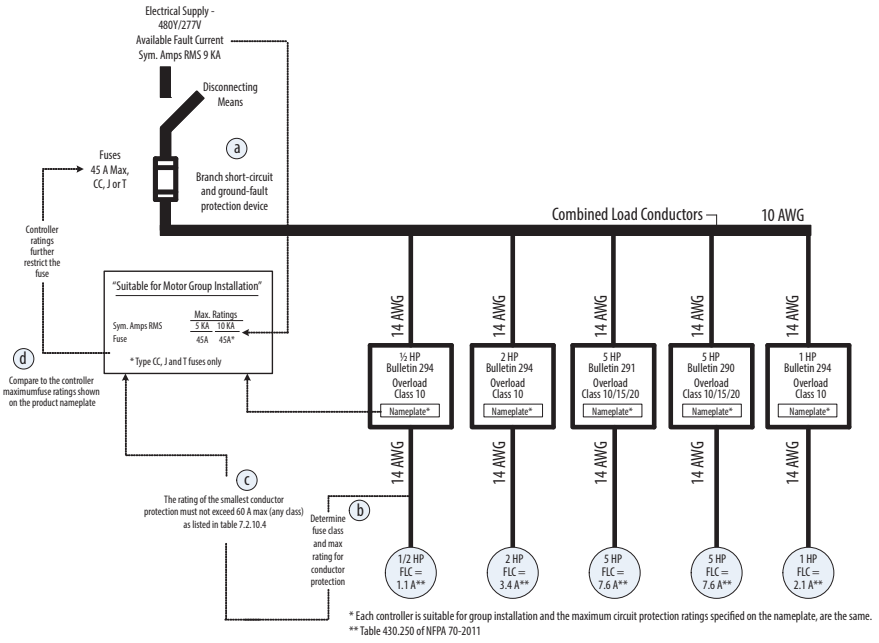
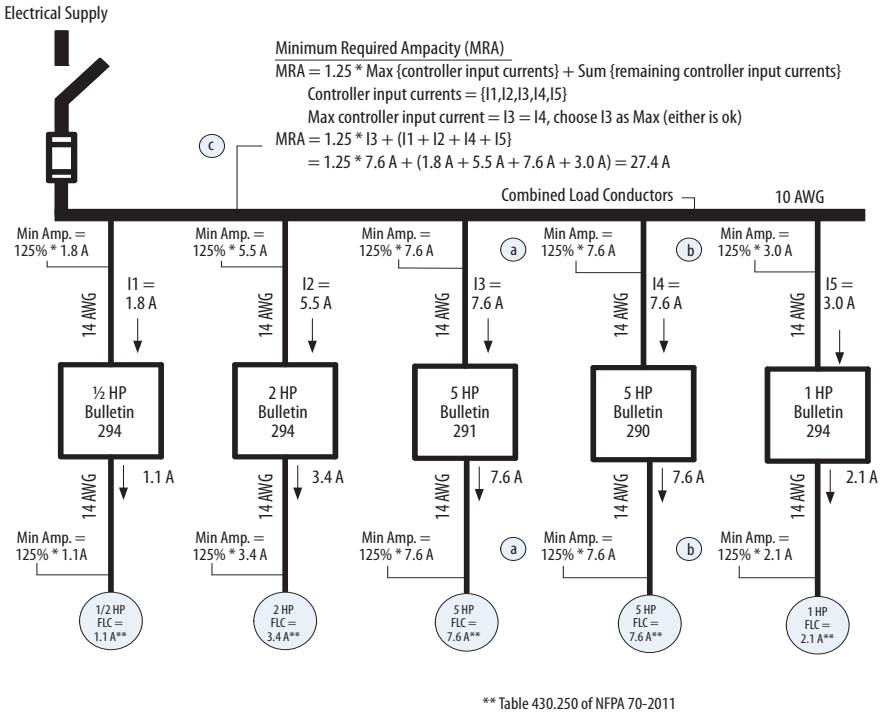


Figure 5 - ArmorStart LT NFPA 79 Multi-motor Branch Circuit Minimum Conductor Ampacity



** Table 430.250 of NFPA 70-2011

Requirement One: Controller Ratings

The motor controllers and overload relays must be Listed for group installation. The maximum fuse rating for branch circuit protection must be specified.

To apply the ArmorStart LT motor controllers in the multiple-motor branch circuit that is shown in Figure 4, 7.2.10.4(1) must be satisfied; each controller must be Listed for group installation with specified maximum branch-circuit protection. The UL Listing for each ArmorStart LT motor controller confirms that it (includes its integral overload relay and motor disconnecting means) is suitable for motor group installation with specified fuses, that satisfy 7.2.10.4(1). The Bulletin 290E and 291E controllers are Listed for group installation according to UL 508, *Industrial Control Equipment*. The Bulletin 294E controllers are Listed for group installation according to UL 508C, *Power Conversion Equipment*.

Referring to Figure 5 (a) indicates the markings on the nameplate that satisfy 7.2.10.4(1). The marking "Suitable for Motor Group Installation" satisfies the requirement to be Listed for group installation. The ratings that are located beneath the description "Max. Ratings" are the specified maximum branch circuit protection. The (a) beside the fuse(s) indicates that the maximum protection that is specified on the nameplate applies to these fuse(s).

Requirement Two: Conductor Short Circuit and Ground Fault Protection

The fuse must protect the conductors for short-circuit faults and ground faults.

Referring to Figure 4, 7.2.10.4(2) must be satisfied. The fuse, as indicated by the description in Figure 4 (a), is the branch short-circuit and ground-fault protection device. The word circuit means the branch circuit. The conductors of the branch circuit start at the load side of the fuses and end at the input to the motor, including the conductors between the motor controllers and the motor. The smallest conductor in the circuit is any one of the 14 AWG conductors that supply each controller and motor. The note at (b) indicates that the conductor protection is based on the smallest conductor, 14 AWG. Referring to NFPA 79, Table 7.2.10.4, a 14 AWG conductor can be used in a circuit that is protected by a fuse

of any class having a rating of 60 A or less (c). Therefore, selecting a fuse of any class with a maximum rating of 60 A satisfies the conductor protection requirement of 7.2.10.4(2).

The value that is specified in NFPA 79, Table 7.2.10.4 is the maximum fuse rating that 7.2.10.4(2) permits to protect that size of conductor. The fuse rating can be set to the maximum value given by NFPA 79, Table 7.2.10.4 for the smallest conductor without further justification. However, if any controller or other component has a maximum fuse rating that is less than the NFPA 79, Table 7.2.10.4 value, the maximum fuse rating protecting the branch circuit must be reduced to the lower value so that all components are applied according to their ratings. For example, as shown in Requirement Three, a lower value might be necessary to protect the motor controller within its ratings because its specified maximum protection is less than the rating that NFPA 79, Table 7.2.10.4 permits for the smallest circuit conductor. Another reason to use a lower fuse rating is to provide more conservative conductor and controller protection. However, in all cases it is important to make sure that the ampere rating is sufficient to start and operate the motors without nuisance opening of the fuse(s).

The note at (b) points to the conductor on the output of the 0.5 Hp Bulletin 294E controller to emphasize that the smallest conductor in the circuit includes the conductors between each controller and motor. This includes the output of the variable-frequency AC drive-based Bulletin 294E controllers, even though these drives have electronic short-circuit protection. According to NFPA 79, the fuse, and not the drive's electronic short-circuit protection, provides the short-circuit fault and ground-fault protection for these output conductors.

Generally, connecting a smaller conductor to a larger conductor requires the installation of fuses at the connection. This connection can be made without the fuse, in some cases, by using a tap rule that indirectly protects the smaller conductor by limiting two things: the ratio of the ampacity of the larger conductor to the ampacity of the smaller conductor and the maximum length of the smaller conductor (see for example, 7.2.8.2). When applying 7.2.10.4(2), such a tap rule is not applicable or necessary. In Figure 4, the smaller 14 AWG conductors can be connected to combined load conductors of any size because 7.2.10.4 does not indirectly protect the smaller conductor by limiting the ratio of the larger to smaller conductor ampacities and the conductor length. Instead, NFPA 79, Table 7.2.10.4 protects the smallest conductor directly by specifying the maximum fuse rating that can protect a branch circuit that contains a conductor of that size.

Requirement Three: Controller Short-circuit and Ground-fault Protection

Each motor controller must be protected according to its own ratings; that is, applied in accordance with its Listing.

See (d) in Figure 4. The characteristics of the fuse(s) permitted to protect the conductors (see Requirement 2) must now be compared to the characteristics in the ratings of the controller. To comply with the Listing of each motor controller and overload relay, the fuse(s) must comply with the maximum branch-circuit protection that is specified in the controller markings. Therefore, the fuse(s) must be of a class that is marked on all controllers and the fuse rating(s) must not exceed the rating that is marked on any of the controllers. The markings of each controller specify that a fuse having a maximum rating of 45 A can protect the motor controller. When connecting to an electrical supply having an available fault current of 5000 A or less, the class of the fuse is not specified and can be any class. When connecting to an electrical supply having an available fault current from 5000 to 10000 A, the class of the fuse must be CC, J, or T. Since the electrical supply has an available fault current of 9000 A, selecting a Class CC, J, or T fuse with a rating of 45 A or less verifies that each motor controller is applied within its own ratings.

To protect the smallest conductor in the circuit, the fuse rating must not exceed the rating that is permitted by 7.2.10.4(2). Selecting a Class CC, J or T fuse with a rating of 45 A, because it is less than 60 A, also protects the conductors (see Requirement 2). Although the ArmorStart LT products presently have a maximum fuse rating of 45 A, future controllers can have maximum fuse ratings that exceed 60 A. In this case, the maximum fuse rating is limited by the rating that protects the 14 AWG conductors, 60 A. The maximum rating that is permitted for the controller, 45 A, can be reduced for more conservative protection, provided that nuisance opening of the fuses does not occur.

In this application technique, a fuse having a rating of any class means a fuse having the let-through characteristics of a Class RK-5 fuse. Class RK-5 fuses are assumed to have the maximum let-through of any class of fuse. For this reason, the ArmorStart LT motor controllers that are marked for use with fuses, without a restriction to a particular class, have been tested with and are intended to be used with RK-5 Class fuses. Fuses of a class that have lower let-throughs than Class RK-5, such as Class CC, J, or T, are also acceptable. A fuse having a rating of any class, also restricts the fuse to those that have been evaluated for use as branch-circuit protection devices. This means that semiconductor fuses, used to protect power electronic equipment, or supplemental fuses cannot be used to protect the multiple-motor branch circuit.

Four complementary ratings are relevant to the branch circuit protection reference in 7.2.10.4(1). They are: the fuse class, the maximum fuse rating, the voltage rating and connection of the source (480Y/277 V), and the available fault current of the source. Applying the controllers according to these four ratings means that a fault on the output of all controllers, and internal faults for Bulletin 294 controllers, will not result in a shock or fire hazard.

In this example, the assumption is made that the available fault current at the controller is that of the source on the line side of the fuses. Although the wiring impedance between the fuses and the first controller reduces the fault current available at the controllers, this reduction is considered negligible by assuming the first controller, the 0.5 Hp, Bulletin 294 controller, is very close to the fuses.

Requirement Four: Overload Protection

The motors, conductors, and controllers must be protected against motor overload conditions as noted in 7.3.1 and 7.3.1.1 of NFPA 79.

Each ArmorStart LT motor controller incorporates an integral overload relay. This overload function must be set in accordance with Article 430, Part III of NFPA 70 (NEC). Selecting the ampacity of the circuit conductors appropriately (see Requirement 5) makes sure that the overload relays, when set according to 7.3.1.1, will protect the conductors against overheating due to motor overloads.

Each individual controller overload relay directly protects the conductors that are connected to the input and output of that controller and the motor that the controller supplies. The combined load conductor is protected by the tripping of one or more of the controller overload relays, that remove(s) the overloaded motor(s) before the combined load conductor overheats.

Requirement Five: Conductor Ampacity

The minimum ampacity of conductors.

In Figure 5, (a), (b), and (c) explain the method for calculating the minimum required conductor ampacity for each of these conductors: input and output conductors of Bulletin 290E and 291E controllers (a), input and output conductors of Bulletin 294E controllers (b), and combined load conductors that supply Bulletin 290E, 291E, and 294E controllers (c). The currents I1 through I5 are the input currents to the controllers. For the Bulletin 290E and 291E controllers, these currents are the same as the output motor currents. For the Bulletin 294E controllers, these currents are the rated input currents.

The example does not address conditions of use such as an ambient temperature exceeding 30 °C or more than three current-carrying conductors in a cable or raceway. In a particular application, these conditions of use might require derating of the ampacity that is given in Table 12.5.1. This example assumes that, under the conditions of use, both conductors have sufficient ampacity for the application. This means the 14 AWG conductors have an ampacity rated no less than 9.5 A and the 10 AWG conductors have an ampacity rated no less than 27.4 A.

Input and Output Conductors for Mechanical Controllers (a)

For ArmorStart models that use an electromechanical contactor to control the motor, the input current like the output current, is simply the current to the motor. Therefore, the minimum conductor ampacity for both input and output conductors is 125% of the motor full-load current rating, as specified in the text of 12.5.3 (a).

Referring to Figure 5, the full-load current rating of a three-phase, 460 V, 5 Hp induction motor is 7.6 A. Using this value, both the input and output conductors must have an ampacity that is not less than 125% of 7.6 A (9.5 A).

Input and Output Conductors for Variable Frequency Drives (b)

ArmorStart models that consist of a variable-frequency AC drive, are used to control the motor. These drives use a power conversion method that generates input currents that are larger than the output currents. The input currents are larger because, unlike the output currents to the motor, they are not sinusoidal. Consequently, when determining the minimum ampacity of the input conductors, the requirement of 12.5.3 must be based on the rated input current of the controller, rather than the full-load current rating of the motor. Therefore, the minimum ampacity of the input conductors must be 125% of the controller rated input current, while the minimum ampacity of the output conductors must be 125% of the motor full-load current rating.

Referring to Figure 5, the 1 Hp Bulletin 294E controller has a rated input current of 3.0 A. Using the rated input current, the conductors from the combined load conductors to the controllers must have an ampacity of 125% of 3.0 A (3.75 A). The output conductors must have an ampacity of 125% of 2.1 A (2.6 A).

Combined Load Conductors (c)

The requirement for the minimum ampacity of the combined load conductors is given by 12.5.4. When the combined load conductors supply one or more Bulletin 294E controllers, the minimum ampacity calculation of 12.5.4 must be made by substituting the rated input current of the Bulletin 294E controllers for the full-load current rating of the motors that these controllers supply.

In Figure 5, the currents I1, I2, I3, I4, and I5 are the input currents to each controller. I3 and I4 are the full-load current ratings of the 5 Hp motors. I1, I2, and I5 are the rated input currents of the Bulletin 294E controllers. Referring to the explanatory text (c) in Figure 5, the method for calculating the minimum ampacity of the combined load conductors follows:

1. Multiply the largest input current to any controller – Bulletin 290E, 291E, or 294E - by 125%. In this case, the input currents to the Bulletin 290E and 291E controllers, I3 and I4, are the largest, 7.6 A. Because they are the same, either can be used. Choose I3 to calculate 125% of the maximum. 125% of 7.6 A is 9.5 A.
2. Sum the remaining input currents (I1, I2, I4, I5) for a total of 17.9 A.
3. Add the result from the first step to the result from the second for a total of 27.4 A.

The minimum ampacity of the combined load conductors is 27.4 A.

The input currents to the Bulletin 294E motor controllers are larger than the output currents to the motor because the input currents contain harmonics that result from the power conversion process. This harmonic content and the magnitude of the resulting non-sinusoidal input currents depend on the impedance of the electrical supply. The value that is specified for the rated input current is the maximum value over the range of possible supply impedances. For this reason, the magnitude of current measured on a particular electrical system might be less than the specified value.

Conclusion

In conclusion, Group installation means that a single set of fuses or a single circuit breaker protects a branch circuit that supplies two or more motors and their controllers. Both NEC and NFPA 79 have rules for installing controllers in these multiple-motor branch circuits. Both also have special rules for controllers that are not Listed for Group installation and general rules for controllers that are Listed for Group installation. These rules are found in NEC 430.53(A), 430.53(B), and 430.53(C)(2)(b) and in NFPA 79 7.2.10.2, 7.2.10.3, and 7.2.10.4(1). In general multiple-motor branch circuits, installing a motor controller that is not marked "Suitable for motor group installation..." does not comply with the NEC and NFPA 79. However, products with the following markings are allowable:

1. listed factory assembly
2. separate assemblies listed for such use

Installing a controller without the "Suitable for motor group installation" marking does not comply with NEC or NFPA 79 because its Listing only covers individual-motor circuit installations. For this case, the installer must add a separate protective device that is sized for the motor that the drive serves, in each of the drive's input circuits.

Additional Resources

These documents contain additional information concerning related products from Rockwell Automation.

Resource	Description
Group Installation Listing Requirements for Drives and Contactor-based Motor Controllers, publication 280-WP001	Provides details for a Motor Controller being Listed for Group Installations
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation® industrial system.
Product Certifications website, rok.auto/certifications	Provides declarations of conformity, certificates, and other certification details.

You can view or download publications at http://www.rockwellautomation.com/global/literature-library/overview.page. To order paper copies of technical documentation, contact your local Allen-Bradley distributor or Rockwell Automation sales representative.

Notes:

Rockwell Automation Support

Use the following resources to access support information.

Technical Support Center	Knowledgebase Articles, How-to Videos, FAQs, Chat, User Forums, and Product Notification Updates.	www.rockwellautomation.com/knowledgebase
Local Technical Support Phone Numbers	Locate the phone number for your country.	www.rockwellautomation.com/global/support/get-support-now.page
Direct Dial Codes	Find the Direct Dial Code for your product. Use the code to route your call directly to a technical support engineer.	www.rockwellautomation.com/global/support/direct-dial.page
Literature Library	Installation Instructions, Manuals, Brochures, and Technical Data.	www.rockwellautomation.com/literature
Product Compatibility and Download Center (PCDC)	Get help determining how products interact, check features and capabilities, and find associated firmware.	www.rockwellautomation.com/global/support/pcdc.page

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Rockwell Automation maintains current product environmental information on its website at http://www.rockwellautomation.com/rockwellautomation/about-us/sustainability-ethics/product-environmental-compliance.page.

Rockwell Otomasyon Ticaret A.Ş., Kar Plaza İş Merkezi E Blok Kat:6 34752 İçerenköy, İstanbul, Tel: +90 (216) 5698400

www.rockwellautomation.com

Power, Control and Information Solutions Headquarters

Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
Europe/Middle East/Africa: Rockwell Automation NV, Pegasus Park, De Kleetlaan 12a, 1831 Diegem, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
Asia Pacific: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

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