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Manual Motor Protectors & Combination Motor Controllers

Application Note

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Applications:

Manual Motor Starter

Manual Motor Disconnect

IEC Circuit Breaker (European Market)

NEC Group Installation Motor Starter

UL 508 Type E Self-Protected Manual Combination Starter

UL 508 Type F Combination Motor Controller (CMC)

IEC Type 2 Coordination

Abstract:

The purpose of this paper is to explain the main applications for Manual Motor Protectors and Combination Motor Controllers. These applications include NEC Group Motor installations, UL 508 Type E Self-Protected Manual Combination Starters, UL 508 Type F Combination Motor Controllers (CMCs), and Type 2 Coordination.

Manual Motor Protectors and Combination Motor Controllers

History and Overview

Manual Motor Protectors (MMPs) were introduced in the United States in the mid-1980s. Since their introduction they have experienced rapid market growth in the U.S., especially with Original Equipment Manufacturers (OEMs).

In the past, they have also been referred to as Manual Motor Starters and Protectors, IEC Circuit Breakers, Motor Starter Protectors, or Manual Motor Controllers. Today, depending on their test ratings and certifications, they are UL listed as UL 508 Type E Self-Protected Manual Combination Starters or UL 508 Type E Self-Protected Combination Motor Controllers and are designed and tested to IEC and UL 508 Type E standards. Coupled with a contactor, the MMP creates a UL 508 Type F Combination Motor Controller (CMC).

MMPs differ from traditional NEMA manual motor starters in several ways. In addition to a Class 10, adjustable, bi-metallic overload (NEMA manual starters typically use Class 20 overloads with heaters), the MMPs also include a fixed magnetic short circuit trip mechanism designed to trip at 14 times the maximum current rating of the starter. While this magnetic short circuit trip feature did not allow them to be UL listed as North American circuit breakers per UL 489, it did open up new applications with OEMs such as group motor installations and self-protected manual combination starters.

Applications

MMPs can be used in the following applications:

- Manual Motor Starter
- Manual Motor Disconnect
- IEC Circuit Breaker (European Market only)
- NEC Group Installation Motor Starter
- UL 508 Type E Self-Protected Manual Combination Starter
- UL 508 Type F Combination Motor Controller (CMC)
- IEC Type 2 Coordination

See **Appendix Table 2** for UL508 Construction Type Distinctions.

Manual Motor Starter Applications

The XTPB and XTPR① MMPs can be used in single-phase or three-phase manual motor starter applications. When used in single-phase applications a wire jumper must be added as shown in **Figure 1**.

① Please note that this is not the complete Catalog Number for the MMP. See Catalog CA03407001E for selection information.

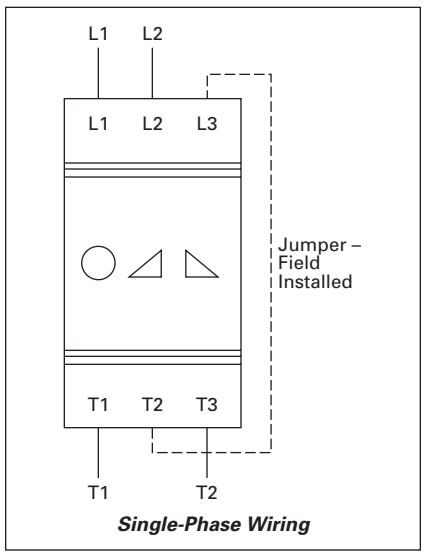


Figure 1. Single-Phase Wiring Diagram – Field Installed Jumper

In the past, manual motor starters were typically selected by motor horsepower at a specific voltage, however, because each MMP has a fixed current range and more than one device may carry the same horsepower range, it is important to choose the proper starter according to the motor full load ampere (FLA) rating on the motor nameplate. This will ensure that the correct overload is selected for the motor.

An auxiliary contact is sometimes used in manual motor starter applications for ON/OFF status indication. Undervoltage release modules are also available for the MMP and play an important safety role in the motor circuit. If power is lost when the manual starter is ON, the undervoltage release module will trip the manual motor starter to the OFF position. When power is restored, the manual motor starter must be turned back ON manually, rather than having the motor start up immediately.

For manual motor starter applications, the MMP is typically sold with an enclosure or front plate. A front plate is used to mount the starter to the front door of an enclosure, machine, or wall cavity. These enclosures and front plates can be NEMA or IEC rated. The classifications for NEMA and IEC enclosures are shown in **Appendix Tables 3**, **4** and **5**.

Enclosed manual motor starters are often specified in commercial and industrial construction quotations for small fans and blower motors. OEM opportunities for enclosed manual motor starters include woodworking machinery, small machine tools, pumps and compressors.

Manual motor starter applications have been declining over the years in favor of magnetic starters. There can be price advantages with manual motor starters, but the AC-3 electrical life of a typical manual motor starter at maximum current is about 100,000 operations versus magnetic starters designed for up to 4 million electrical operations. Magnetic starters also offer the ability to be controlled remotely via the magnetic contactor — typical manual motor starters do not have this capability.

Manual Motor Disconnect Applications

The Cutler-Hammer® XTPR device from Eaton's electrical business is UL/CSA listed as a Self-Protected Manual Combination Starter and has additionally been evaluated for motor disconnect use and is marked as such per Part III of UL 508. This allows its use as an "at-motor" disconnect. See **Figure 2**.

Note: The XTPB manual motor starters are not approved as "at-motor" disconnects.

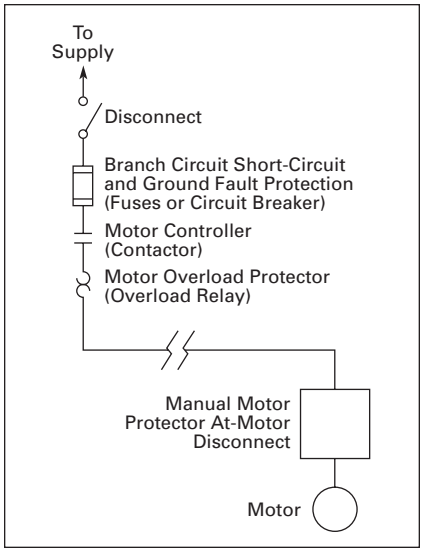


Figure 2. At-Motor Disconnect

Similar to manual motor starter applications, the MMPs are typically used in enclosures or with front plates in manual motor disconnect applications. These applications are large systems, i.e. conveyor systems, with the need for multiple ON/OFF disconnect locations. It is important to note that the MMPs do not meet UL 98 as disconnect switches. However, as a UL 508 Type E or F device (discussed later) with a Thru-the-Door Operator disconnect, they can be used on a branch motor circuit.

IEC Circuit Breaker Applications (European Market only)

The Cutler-Hammer XTPB and XTPR devices meet the requirements of IEC circuit breakers per IEC 60947-2. It is important to note that the MMPs *cannot* be used as North American circuit breakers because they do not meet UL 489 circuit breaker requirements.

However, North American OEMs and panel-builders that export machinery or equipment to Europe can benefit from the MMP IEC certification for their use as circuit breakers. Shunt trip modules are also available as an accessory to remotely stop or turn OFF the MMP.

Group Installation Manual Motor Starter Applications

Group Motor installation is not a new concept. This application technique was established on a formal basis in 1941 as part of NFPA-79 (National Fire Protection Agency). This electrical standard provided an alternative means for meeting branch circuit protection requirements.

Group Motor installations have achieved greater popularity recently because of the introduction of devices, such as MMPs, which combine both overload trip and magnetic short circuit trip functions. Group motor installations are the most widely used application for MMPs in North America. The National Electrical Code (NEC) Article 430.53 provides requirements for Group Motor installation.

A group motor installation consists of two or more motor circuits protected by the same branch circuit short circuit protective device. Such branch circuit short circuit protective devices can either be UL 489 circuit breakers or UL 248 fuses. This differs from the traditional NEC Article 430 (Part IX, IV, VII, III) or NEC 430.52 Rating or Setting for an Individual Motor Circuit, that require a disconnecting means, branch circuit short circuit and ground fault protection, controller and overload protection for each motor circuit. See **Figures 3** and **4**.

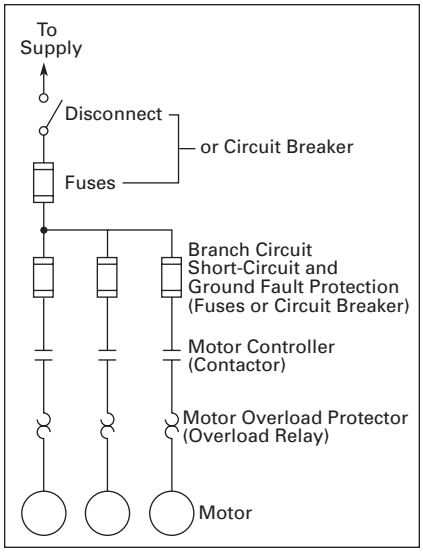


Figure 3. Traditional NEC Requirements for Branch Motor Circuits

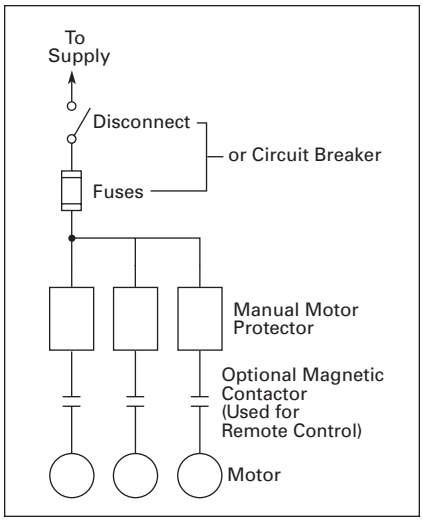


Figure 4. Group Motor Installation

It is important to note that group motor installations eliminate the need for individual branch circuit short circuit protective devices (fuses or circuit breaker) for each motor circuit by using the main short circuit protective device (SCPD). The reduced cost of components, reduced panel size, reduced wiring and assembly charges, and increased time savings with group certified MMPs or Combination Motor Controllers (CMCs), are substantial with group motor installations.

The MMPs, with a magnetic short circuit trip of 14 times the maximum setting of the Class 10 bimetal overload full load ampere adjustment dial, also offer protection against low level faults that some fuses or circuit breakers on the branch circuit may ignore.

A brief summary of the NEC requirements for group motor installations is required to properly apply the MMP or CMC (MMP with contactor).

NEC Article 430.53: Several Motors or Loads on One Branch Circuit:

NEC 430.53 provides exceptions to 430.52 and covers the requirements for group motor installations. Two or more motors or one or more motors and other loads shall be permitted to be connected to the same branch circuit under conditions specified in 430.53(A), (B), or (C) and in one of either 430.53(D)(1), (D)(2) or (D)(3).

IF

430.53(A): Not Over 1 Horsepower

All motors are 1 hp or less, protected at under 20A at 120V or at 15A at 600V or less, the full load amp rating of each motor does not exceed 6 amperes, the device rating marked on the controller is not exceeded, and individual overload protection conforms to 430.22 Single Motor Circuit Conductors

OR

430.53(B): If Smallest Rated Motor Protected

The circuit for the smallest motor is protected per 430.52 Rating or Setting for Individual Motor Circuit; i.e. the branch circuit protective device protecting the group meets 430.52 for the circuit with the smallest motor

OR

430.53(C): Other Group Installations

The complete or separate assembly of properly sized BCPD, controller, and overload devices are tested, listed, and marked for group installation.

XTPR devices comply as follows:

- (C)(1): The MMP acts as the overload device and is UL listed for group installation
- (C)(2): The contactor used for remote operation is UL Listed for use with the MMP in a group installation
- (C)(3): The MMP acts as the IEC "circuit breaker" for the branch and is listed for group installation
- (C)(4): The correct sizing of the upstream SCPD, UL 489 circuit breaker or UL 248 fuses, shall conform to 430.52 and 240.4(B) Protection of Conductors.
- (C)(5): The branch circuit shall be protected by fuses or a circuit breaker having a rating not exceeding that specified in 430.52 for the highest rated motor connected to the branch circuit, plus an amount equal to the sum of the full-load current ratings of all other motors and the ratings of other loads connected to the circuit. Where this calculation results in a rating less than the ampacity of the supply conductors, it shall be permitted to increase the maximum rating of the fuses or circuit breaker to a value not exceeding that permitted by 240.4(B).
- (C)(6): The branch circuit fuses or circuit breakers are not larger than allowed by 430.40 for the overload relay protecting the smallest rated motor of the group.

  In general, the limit is the % FLC of the smallest motor PLUS the sum of the other loads, for fuses or circuit breakers. However, it is very dependent on practice oriented data and the marking on the equipment itself, as noted in (C)(5) and shown in this paper, **Appendix Tables 10** and **11**. 430.40 also refers you back to the marking on the MMP overload relay.

AND

ONE of the following under 430.53(D)

Single Motor Taps:

- (D)(1): The ampacity of conductors to motors are no less than the ampacity of the branch circuit conductors

OR

- (D)(2): The conductors to motors have at least 1/3 the ampacity of the branch circuit conductors (min. per 430.22), are protected from physical damage, and are not more than 25 ft. (7.5m) long from the tap point to the line side of the MMPs [NEC 240.21(B)(2)].

OR

- (D)(3): The tap conductors from the SCPD to each MMP marked "*Suitable for Tap Conductor Protection in Group Installations*" shall have a minimum ampacity of at least 1/10 the ampere rating of the SCPD. These tap conductors shall be 3m (10 ft.) or less, enclosed and protected from physical damage [NEC 240.21(B)(1)]: if not, then the tap conductors shall have an ampacity at least equal to the branch circuit conductors. The wiring on the load side of the MMP is still according to the motor current and 430.22.

It is important to note that not every multi-motor application can use the Group Motor Installation approach. See **Figure 5**, Group Motor Protection adapted per NEC 430.53. The customer should also first analyze the frequency and severity of potential short circuit conditions for each application before deciding if Group Motor Installation is appropriate. While this publication briefly describes some requirements, it is intended for use as a guide only, and not as a substitute for actual customer requirements, or those stated in the National Electric Code, UL File 508 or other agencies.

Example of a group motor installation:

There are [6] three-phase 480V Design B energy efficient motors in our group motor installation. The number of motors and FLA of each motor are as follows:

Table 1. Example Group Installation

Number of Motors	Motor FLA
1	7.6A
2	4.8A
3	1.8A

NEC Table 430.52 Maximum Rating or Setting of Motor Branch Circuit Short Circuit and Ground Fault Protective Devices, provides information on the Percentage of Full-Load Current allowed for Type of Motor and Protective Device. See **Appendix Table 6**.

As mentioned earlier, the NEC 430.53(C)(4) requirement calculates the largest motor FLA times %FLC plus the sum of all other motor FLAs in the group.

If we were using **Dual Element Time Delay fuses** for this BCPD, the theoretical calculation would be:

Largest Motor FLA = 7.6A x 175% = 13.3A

2 Motors of 4.8A FLA= 9.6A

3 Motors of 1.8A FLA= 5.4A

Total FLA = 28.3A

Max. Fuse rating for BCPD= 30A

This application's Total FLA results in a rating less than the ampacity of supply conductors based on a 10 AWG 30A conductor. Therefore, NEC 430.53(C)(4) permits the increase of the maximum rating of the fuses not exceeding 240.4(B). For this group motor installation, 30A fuses would be used as the BCPD.

If we were using an **Inverse Time Breaker**, the theoretical calculation would be as follows:

Largest Motor FLA = 7.6A x 250% = 19.0A

2 Motors of 4.8A FLA = 9.6A

3 Motors of 1.8A FLA = 5.4A

Total FLA = 34.0A

Max. CB for BCPD = 30A

(Based on 10 AWG 30A conductor)

This application's Total FLA results in a rating greater than the ampacity of supply conductors based on a 10 AWG 30A conductor. Therefore, NEC 430.53(C)(4) does not permit the increase of the maximum rating of the circuit breaker not exceeding 240.4(B). For this group motor installation, a 30A circuit breaker would be used as the BCPD.

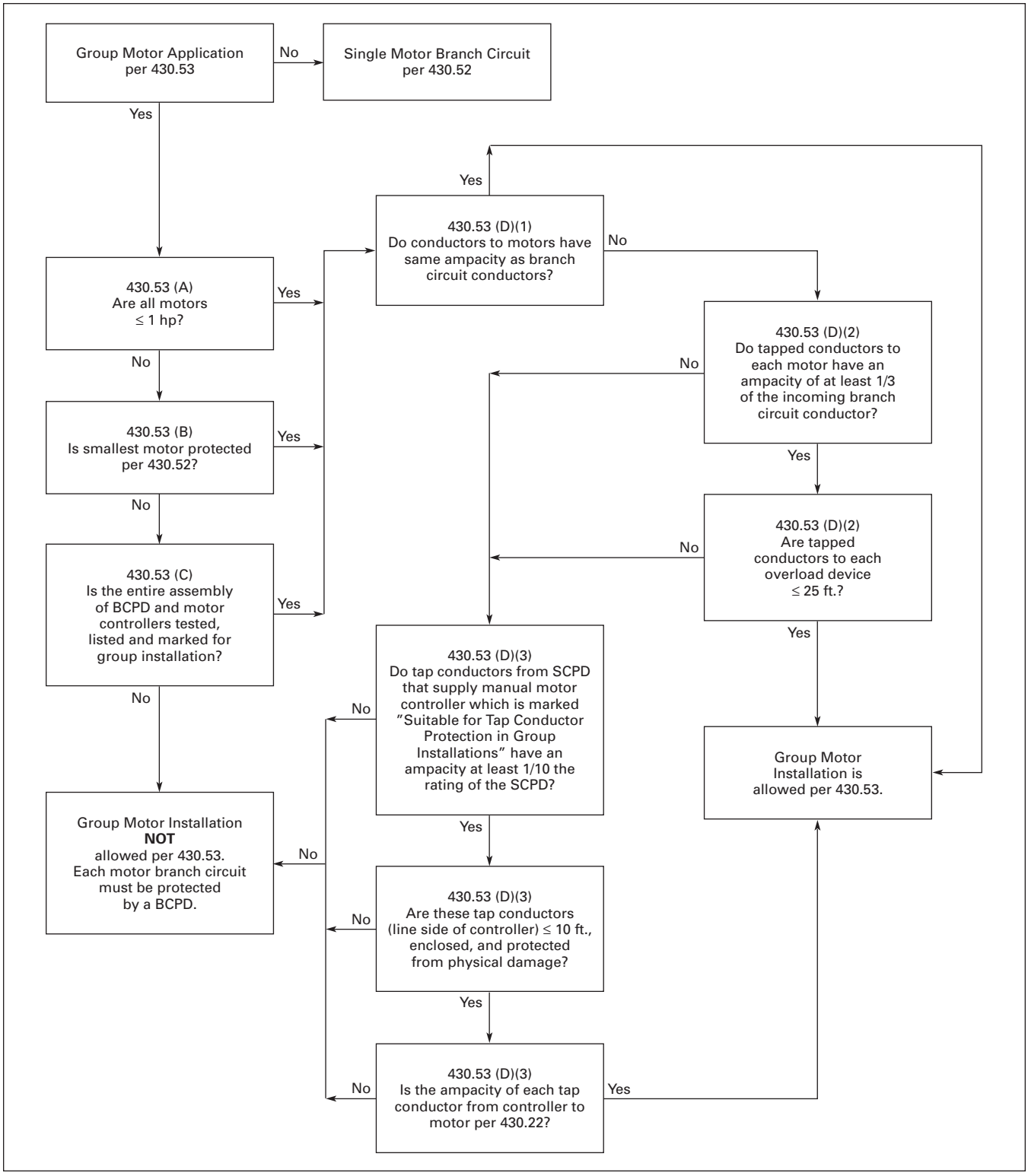


Figure 5. Group Motor Protection adapted from NEC 430.53

Next, we need to evaluate the conductors from the load side of the MMPs to the motor.

NEC 430.53 (D)(1) or (D)(2) or (D)(3), as mentioned earlier, would be evaluated. NEC 430.53 (D)(2) contains the **1/3 tap rule** guideline. See **Appendix Table 7** for more information.

In order to be compliant, the tapped conductors to each motor must have an ampacity of at least 1/3 of the incoming branch circuit conductor, meaning the Motor Conductor ampacity must be greater than the Incoming Conductor ampacity divided by 3. Using our group motor installation example above with circuit breakers and selecting a commonly used 14 AWG wire from the MMPs to the motors, we get an ampacity of 15A per NEC Table 310-16, 240.4(D). In this case, the incoming branch circuit conductors would be limited to 30A maximum or 10 AWG wire since 15A > [30A/3] – compliant with the 1/3 tap rule. If the incoming conductor ampacity and circuit breaker ratings increase, e.g. 8 AWG 55A, the MMP to motor conductor ampacity would have to increase to 12 AWG 20A i.e. 20A > [55A/3] for 1/3 tap rule compliance.

OR

As mentioned previously, the last group rule that can be applied is the 1/10 tap rule under NEC 430.53 (D)(3). This verifies if the tap conductors from the SCPD that supply the MMPs marked "Suitable for Tap Conductor Protection in Group Installations" have an ampacity of at least 1/10 the rating of the SCPD, a maximum length of 10 ft. and are protected for 1/10 tap rule compliance.

For example, if the main SCPD is 200A, the tap conductor ampacity would be a minimum 20A 12 AWG. Also, the conductor ampacity from controller to motor would be sized only according to the motor current per 430.22. See **Appendix Table 8** for more information on tap conductor protection in group applications.

For Group Installations (in-panel SCPD) applying the traditional 1/3 tap rule, the MMPs and CMCs may be used on 480V Delta systems along with 480/277 and 600/347 slash-rated Wye systems. For Group Installations applying the 1/10 tap conductor rule, a maximum 240V Delta is permitted or 480/277 and 600/347 slash-rated Wye systems.

See **Appendix Tables 9** – **10** for SCPD sizing details and determinations for group applications.

Remote Operation

In most group motor installations it is necessary to control a motor automatically or from a remote location. A magnetic contactor, used in conjunction and wired in series with the MMP, provides the control equivalent to a magnetic motor starter. Only test certified magnetic contactors can be used (Mini, IEC or NEMA), as long as the contactor is sized for the FLA and horsepower of the motor. See **Figure 6**.

Finally, some MMP + Contactor assemblies are UL 508 Type F certified as Combination Motor Controllers and are used in the same applications as Type E MMPs, but with remote operation provided by the contactor.

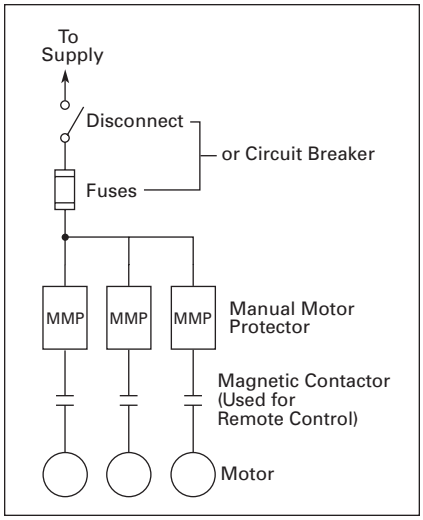


Figure 6. Remote Control with Separate Magnetic Contactors

In applications where all of the motor circuits can be operated at the same time, a single contactor can be used to control or operate all of the motor circuits as long as it is sized large enough to cover the total FLA of all of the motors. See **Figure 7**.

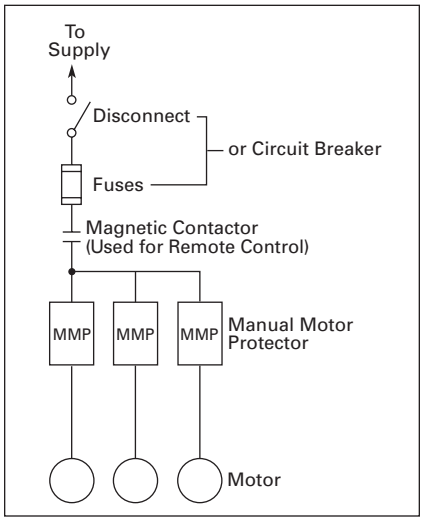


Figure 7. Remote Control with One Magnetic Contactor

UL 508 Type E Self-Protected Manual Combination Starter Applications

Over the past decade, the control and protection of motors has undergone a technical revolution. Conventional UL 508 A, B, C, or D Combination Starters, using fused disconnect switches or molded case circuit breakers, are large, requiring considerable panel space; not modular or field installed; have complicated designs; difficult to assemble; and are more expensive. In the event of short circuit faults, the let through energy (I^2T) and the peak let through current (Ip) of the protective devices are relatively high, which can result in damage to components. The new generation of XTPR UL 508 Type E Self-Protected Manual Combination Starters offer many application advantages:

- Reduced panel space and cost of components
- Reduced wiring and assembly charges
- Short Circuit Protection
- Class 10 Overload Protection
- Superior Type 2 Coordination (No damage and continuous service after a fault)
- Simplified engineering — no need to coordinate with a backup short circuit protective device (often unknown) due to its stand-alone rating
- A global design suitable with current technological control panel advances
- Easy field assembly

Self-protected manual combination starter applications offer additional cost savings over group motor installations because the need for a BCPD is eliminated. In many typical enclosure designs, all that is required is a non-fused disconnect switch (that satisfies UL98) ahead of the self-protected manual combination starters and line side adapter lug assembly (e.g. XTPAXLSA or XTPAXLSAD) on the MMP (when applicable). See **Figure 8** and **Appendix Table 12**.

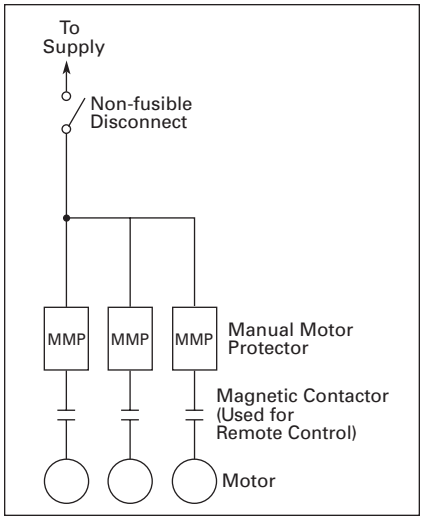


Figure 8. UL 508 Type E with Non-fusible Disconnect

Or, in many new enclosure designs, particularly Distributed Control applications, Type E MMPs can also be used with only an upstream feeder SCPD and line side adapter lug assembly on the MMP (when applicable), and Thru-the-Door Operator accessory including extension shaft, connecting element, and front door Rotary Operating Mechanism. See **Figure 9**.

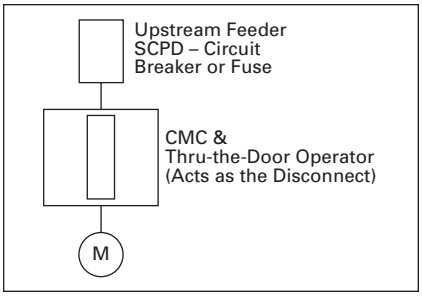


Figure 9. Distributed Control Panel — Type E

Figure 10 shows when the line side adapter lug assembly is necessary based on the required MMP and the application parameters.

The requirements for self-protected manual combination starters are very strict and are outlined in UL 508, Part IV. The test program has its basis in UL 489, Molded Case Circuit Breaker Standard. For example, products tested must complete a rigorous test sequence per Table 82A.1 consisting of short circuit operations and endurance tests. At the conclusion of the test cycle, the products must be operational and tripping functions, both thermal and instantaneous, must be within specifications.

The 1999 National Electrical Code (NEC) permitted the use of self-protected manual combination starters. NEC Article 430.52 (C)(6) Self-Protected Combination Controller allows a self-protected manual combination starter to be used as the BCPD instead of typically used fuses or breakers.

For UL 508 Type E applications (out-of-panel upstream feeder SCPD only), a maximum 240V Delta is permitted or 480/277 and 600/347 slash-rated Wye systems.

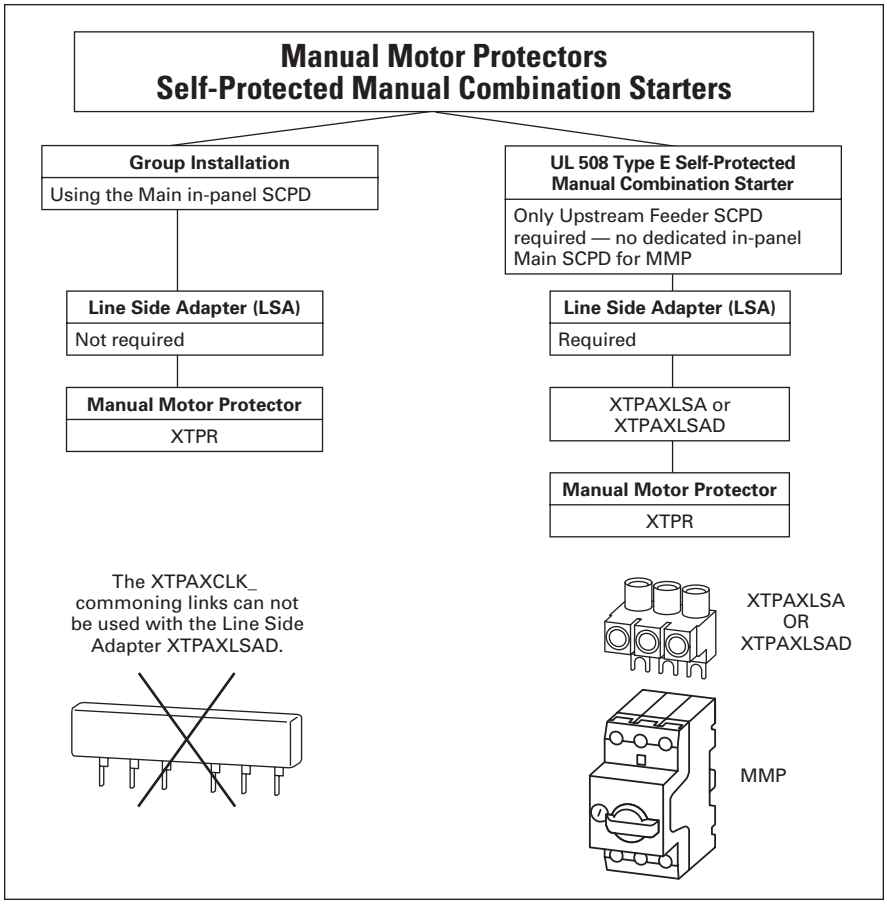


Figure 10. Line Side Adapters — When to Use Them (1 of 2)

Note: Line Side Adapters are not required for non-US applications. Most countries outside of the US classify the MMP as a thermal magnetic circuit breaker.

UL 508 Type F Combination Motor Controller (CMC) Applications

With the addition of a certified contactor to the Type E MMP and meeting the UL 508 Type F requirements, one can use the Type F CMC in the same applications as a Type E MMP with the same overall advantages listed above. See **Figures 11** and **13**. Over the years, this configuration has also been referred to as an Integral Starter, Coordinated Protected Starter, Compact Starter or Integrated Starter. The XTPR MMPs plus XTCE or ***IT.*** Contactors meet UL 508 Type F requirements and are listed as Combination Motor Controllers (the XTPB coupled with a contactor does not meet this standard). The XT CMC has Catalog Number parents of XTFC or XTFR (reversing), while the ***IT.*** CMC has complete device Catalog Number parents of E307/8/9 and E357/8/9 (reversing).

In addition, modular Wiring Connector Link Kits (e.g. XTPAXTPC_ for XT CMCs and C320WC27/45IT/54 for ***IT.*** CMCs) are available between the MMP and Contactor for easy assembly rather than hardwiring the MMP to the contactor. The contactor also provides the following additional benefits:

- Remote Operation
- Longer life than the MMP
- A1, A2 coil access at the bottom
- High Fault Type 2 Coordination without oversizing the contactor with Cutler-Hammer contactors
- Contactor accessories

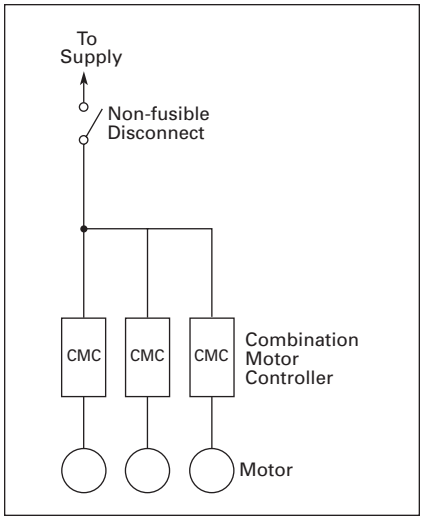


Figure 11. UL 508 Type F with Non-fusible Disconnect

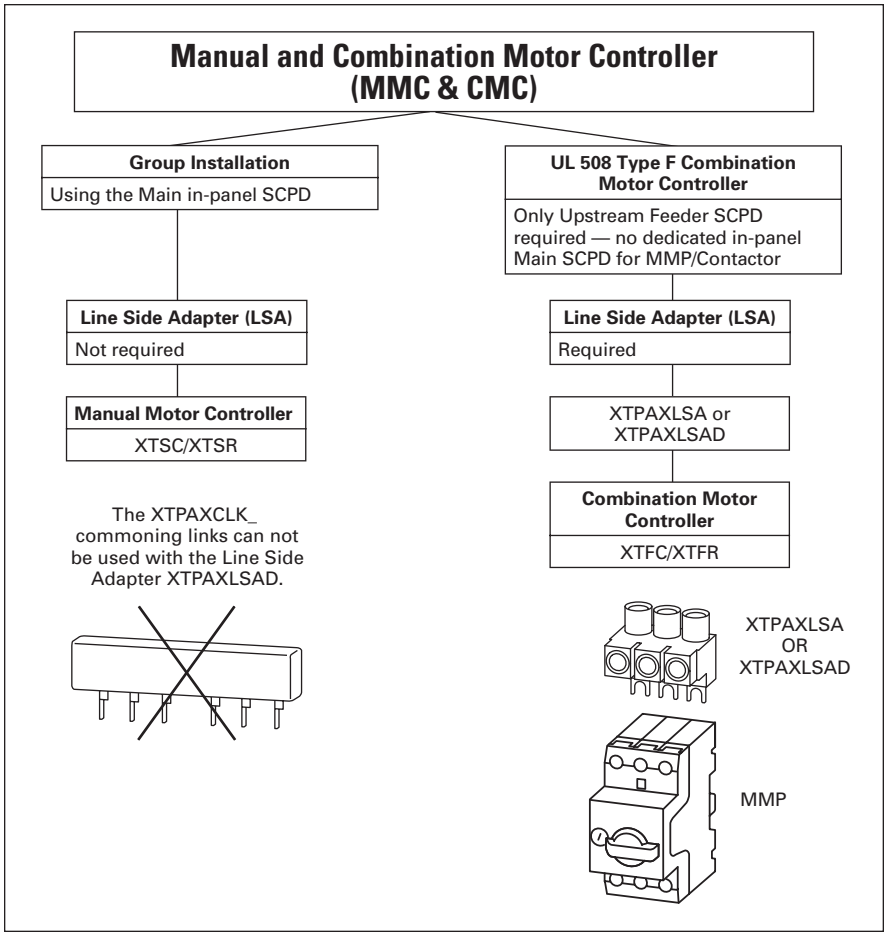


Figure 12. Line Side Adapters — When to Use Them (2 of 2)

Note: Line Side Adapters are not required for non-US applications. Most countries outside of the US classify the MMP as a thermal magnetic circuit breaker.

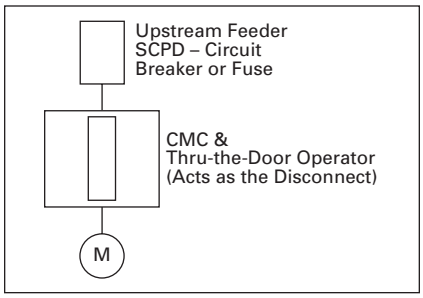


Figure 13. Distributed Control Panel — Type F

Type-2 Coordination

In IEC Standard 60947-4-1, under the protection scheme called "Type 2 Coordination", the starter must exhibit no damage following a major short circuit fault within its ratings and the starter should be able to be returned to proper service without replacing any parts. "Type 2 Coordination" minimizes lost production and unscheduled disruptions that result from downtime when replacing or repairing a starter. As described under self-protected manual combination starters above, the XTPR as well as the complete Type F CMC (MMP and Contactor) meet the requirements of "Type 2 Coordination".

Note: The XTPB is a "Type 1 Coordination" starter. Under "Type 1 Coordination", starters may not be suitable for further service without repair or replacement of parts.

Conclusion

This paper served as an educational piece to help explain the main applications for Cutler-Hammer Manual Motor Protectors from Eaton Electrical. There are many benefits to be gained from the use of XTPR MMPs as Type E Self-Protected Manual Combination Starters, Type F Combination Motor Controllers (when coupled with a contactor), e.g. XTFC/XTFR, or in Group Installations.

Benefits include:

1. Individual disconnects, fuses, fuse blocks or circuit breakers can be reduced or eliminated for each branch motor circuit.
2. Panel space savings are significant.
3. Wiring and installation costs and time are substantially reduced.
4. Simplified engineering — no need to coordinate with a backup overcurrent protective device due to stand-alone ratings.
5. A design more in line with current technological control panel advances used throughout the world.
6. Type 2 Coordination.

Appendix

UL assigns "Construction Types" (letters A – F) to the combination starters based on different component parts. See **Table 2.**

Table 2. UL 508 File Table 76.2

Component Parts	Construction Type					
	A	B	C	D	E	F
Disconnecting Means	Manual Disconnect (UL 98 or UL 1087)	Manual Disconnect (UL 98 or UL 1087)	Circuit Breaker (UL 489)	Circuit Breaker (UL 489)	Self-Protected Manual Combination Starter (UL 508)	Combination Motor Controller (UL 508)
Short Circuit Protective Device	Fuse (UL 248 Series)	Motor Short Circuit Protector (UL 508)	Inverse-Time Circuit Breaker (UL 489)	Instantaneous-Trip Circuit Breaker (UL 489)	Included	Included
Motor Controller	Magnetic (UL 508)	Magnetic (UL 508)	Magnetic (UL 508)	Magnetic (UL 508)	Optional	Magnetic (UL 508)
Overload Protection	Overload Relay (UL 508)	Overload Relay (UL 508)	Overload Relay (UL 508)	Overload Relay (UL 508)	Included	Included

Table 3. NEC Table 430.91 Motor Controller Enclosure Selection

For Outdoor Use										
Provides a Degree of Protection Against the Following Environmental Conditions	Enclosure Type Number ①									
	3	3R	3S	3X	3RX	3SX	4	4X	6	6P
Incidental contact with the enclosed equipment	■	■	■	■	■	■	■	■	■	■
Rain, snow and sleet	■	■	■	■	■	■	■	■	■	■
Sleet ②	—	—	■	—	—	■	—	—	—	—
Windblown dust	■	—	■	■	—	■	■	■	■	■
Hosedown	—	—	—	—	—	—	■	■	■	■
Corrosive Agents	—	—	—	■	■	■	—	■	—	■
Temporary Submersion	—	—	—	—	—	—	—	—	■	■
Prolonged Submersion	—	—	—	—	—	—	—	—	—	■

For Indoor Use										
Provides a Degree of Protection Against the Following Environmental Conditions	Enclosure Type Number ①									
	1	2	4	4X	5	6	6P	12	12K	13
Incidental contact with the enclosed equipment	■	■	■	■	■	■	■	■	■	■
Falling dirt	■	■	■	■	■	■	■	■	■	■
Falling liquids and light splashing	—	■	■	■	■	■	■	■	■	■
Circulating dust, lint, fibers, and flyings	—	—	■	■	—	■	■	■	■	■
Settling airborne dust, lint, fibers, and flyings	—	—	■	■	■	■	■	■	■	■
Hosedown and splashing water	—	—	■	■	—	■	■	—	—	—
Oil and coolant seepage	—	—	—	—	—	—	—	■	■	■
Oil or coolant spraying and splashing	—	—	—	—	—	—	—	—	—	■
Corrosive Agents	—	—	—	■	—	—	■	—	—	—
Temporary Submersion	—	—	—	—	—	■	■	—	—	—
Prolonged Submersion	—	—	—	—	—	—	■	—	—	—

① Enclosure type number shall be marked on the motor controller enclosure.
② Mechanism shall be operable when ice covered.

The degree of protection is indicated by two letters (IP) and two numerals. International Standard IEC 529 contains descriptions and associated test requirements that define the degree of ingress protection each numeral specifies. **Appendix Tables 4** and **5** indicate the *general* degree of protection:

Table 4. 1st Characteristic Numeral

Protected against contact and penetration of solid bodies.	
0	Not protected.
1	Protection against solid objects greater than 50 mm.
2	Protection against solid objects greater than 12 mm.
3	Protection against solid objects greater than 2.5 mm.
4	Protection against solid objects greater than 1.0 mm.
5	Dust protected.
6	Dust-tight.

Table 5. 2nd Characteristic Numeral

0	Not protected.
1	Protection against dripping water.
2	Protection against dripping water when tilted up to 15 degrees.
3	Protection against rain.
4	Protection against splashing water.
5	Protection against water jets.
6	Protection against heavy seas.
7	Protection against the effects of immersion.
8	Protection against submersion.

Example: IP41 describes an enclosure that is designed to protect against the entry of tools or objects greater than 1 mm in diameter and to protect against vertically dripping water under specified test conditions.

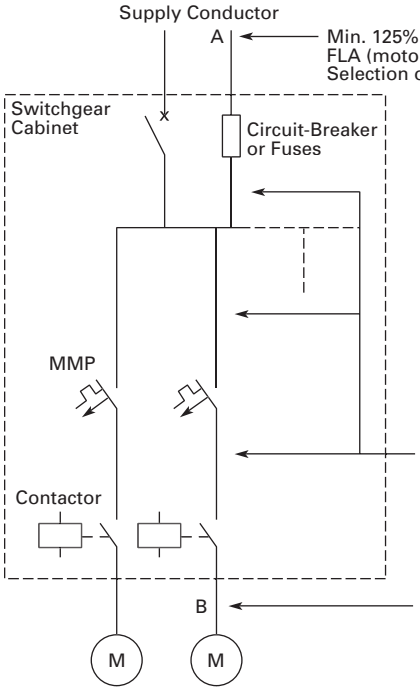
Table 6. Excerpt from NEC Table 430.52 Maximum Rating or Setting of Motor Branch Circuit Short Circuit and Ground Fault Protective Devices

Type of Motor	Percentage of Full-Load Current			
	Non-time Delay Fuse ③	Dual Element (Time Delay Fuse) ③	Instantaneous Trip Breaker	Inverse Time Breaker ④
Design B Energy Efficient	300	175	1100	250

③ Values also apply to Time-Delay Class CC fuses.

④ Values also cover the ratings of nonadjustable inverse time types of circuit breakers that may be modified as in 430.52(C), Exception No. 1 & 2.

Table 7. Group Motor Installation (1/3 Tap Rule) Applications



Min. 125% of the largest motor full load current plus the sum of all other motor full load currents (NEC §430.24)
FLA (motor full load current) from NEC table 430.150
Selection of conductor size acc. to NEC table 310.16 (75°C)

FLA (motor full load current) from UL 508A table 50.1
Selection of the circuit-breaker acc. to UL 508A:
Min. 125% of the sum of all motor full load currents (§30.2.1)
Max. 250% of the largest motor full current plus the sum of all other load currents (§31.4.1 C 1)

Selection of fuses acc. to UL 508A:
Min. 125% of the largest motor full load current plus the sum of all other load currents (practice-oriented data)
time delayed: max. 175% of the largest motor full load current plus the sum of all other load currents (§31.4.1 C 1)
non-time delayed: max. 300% of the largest motor full load current plus the sum of all other load currents (§31.4.1 C 1)

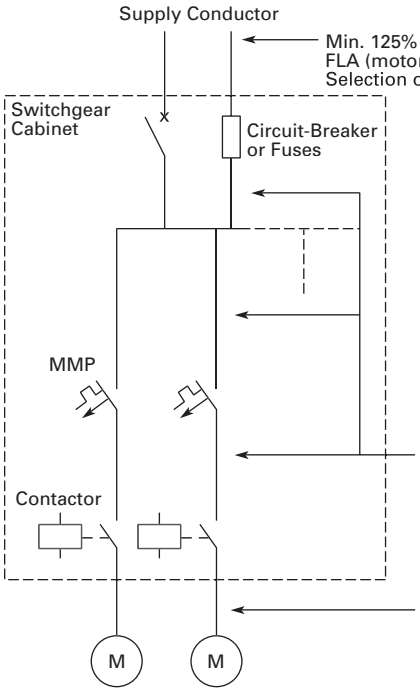
Selection acc. to 100% of the motor full load current (data on rating plate)

Min. 100% of the motor full load current (UL 508A table 50.1)
Selection of conductor size acc. to UL 508A table 29.1
All internal conductors dimensioned for 90°C (UL 508A §29.2.1)

Selection acc. to horsepower rating (UL 508A §33.2)

For main tap conductors to MMP ≤ 25 feet (7.62 m): B > A/3
For main tap conductors to MMP > 25 feet (7.62 m): B = A
A and B are the ampacities of the indicated conductors
Selection of conductor size acc. to NEC table 310.16 (75°C)

Table 8. Suitable for Tap Conductor Protection in Group Applications Configuration



Min. 125% of the largest motor full load current plus the sum of all other motor full load currents (NEC §430.24)
FLA (motor full load current) from NEC table 430.150
Selection of conductor size acc. to table NEC 310.16 (75°C)

FLA (motor full load current) from UL 508A table 50.1
Selection of the circuit-breaker acc. to UL 508A:
Min. 125% of the sum of all motor full load currents (§30.2.1)
Max. 250% of the largest motor full current plus the sum of all other load currents (§31.4.1 C 1)

Selection of fuses acc. to UL 508A:
Min. 125% of the largest motor full load current plus the sum of all other load currents (practice-oriented data)
time delayed: max. 175% of the largest motor full load current plus the sum of all other load currents (§31.4.1 C 1)
non-time delayed: max. 300% of the largest motor full load current plus the sum of all other load currents (§31.4.1 C 1)

Selection acc. to 100% of the motor full load current (data on rating plate)

Min. 100% of the motor full load current (UL 508A table 50.1)
Selection of conductor size acc. to UL 508A table 29.1
All internal conductors dimensioned for 90°C (UL 508A §29.2.1)

Selection acc. to horsepower rating (UL 508A §33.2)

Min. 125% of the motor full load current (NEC §430.22 (A))
FLA (motor full load current) from NEC table 430.150
Selection of conductor size acc. to NEC table 310.16 (75°C)

Table 9. XTPB 600V Max. Interrupting Ratings — Group Motor Applications

Catalog Number	Adjustable Thermal Current Range (Amperes)	Max. RMS Symmetrical Short Circuit Current 600V AC (kA)	Maximum Protective Device Amperes	
			Circuit Breaker	Fuse
XTPBP16BC1	.10 – .16	50	600	600
XTPBP25BC1	.16 – .25	50	600	600
XTPBP40BC1	.25 – .40	50	600	600
XTPBP63BC1	.40 – .63	50	600	600
XTPB001BC1	.63 – 1.0	50	600	600
XTPB1P6BC1	1.0 – 1.6	50	600	600
XTPB2P5BC1	1.6 – 2.5	50	600	600
XTPB004BC1	2.5 – 4.0	50	600	600
XTPB6P3BC1	4.0 – 6.3	50	600	600
XTPB010BC1	6.3 – 10	10 ③	125 ①②	150 ①②
XTPB012BC1	8.0 – 12	10 ③	125 ①	150 ①
XTPB016BC1	10 – 16	10 ③	125 ①②	150 ①②
XTPB020BC1	16 – 20	10 ④	125 ①	150 ①
XTPB025BC1	20 – 25	10 ④	125 ①	150 ①

① 600A with current limier.
② 22kA 600V AC.
③ 50kA with current limiter.
④ 18kA with current limiter.

Table 10. Group Application SCPD Determination

Determination of maximum short circuit protective device (SCPD) in group applications using the "1/3 rule" of NEC 430.53(D)(2) and Par. 52A.1.2 of UL 508 as applied to XTPR MMP devices.

1. The ampacity of the largest wire size that the MMP will hold determines the maximum ampacity of the largest branch circuit wire. The ampacity of the branch circuit wire is limited to a maximum of 3 times the ampacity of the wire in the MMP.
2. Since the branch circuit wire is a maximum of 3 times the smallest tap conductor wire, the wire in the MMP under consideration will be the smallest tap conductor wire. Therefore, the largest motor load is potentially on another tap conductor.
3. The maximum current carried by the tap conductor to the MMP is the ampacity of the wire in the MMP (from #1 above) divided by 1.25.
4. The maximum current carried by the branch circuit conductor is required to be:
   a. 125% of the FLA of the largest motor in the group, plus
   b. all other loads (including the current to the MMP)
5. The maximum possible motor current (FLA) that can be supplied to the largest motor load (on another tap other than the one to the MMP) is then determined by subtracting the maximum current carried by the tap conductor to the MMP (determined in #4b above) from the ampacity of the branch circuit conductor, and then dividing by 1.25 (because of the requirement in #4a above.)
6. The branch circuit protective device is permitted to be the sum of the value of the protective device for the largest motor load plus all other loads. This would be 400% of the FLA of the largest motor in the group (#5 above) times 4, plus the maximum current for the MMP (#4b above.)

Example:

MMP with terminals to accept #10 AWG Wire, with a dial setting of 17 – 22 amps: (#10 AWG has an ampacity of 30 amps)

First, a calculation based on a setting of 17 amps:

1. The Branch Circuit conductor would be 3 times 30, or 90 amps (Step 1 above).
2. The maximum current through the MMP would be 17 amps.
3. The maximum possible motor current to the largest motor would be 90 minus 17, divided by 1.25, or 58.4 amps. (Step 5 above).
4. The branch circuit protective device would be 4 times 58.4 amps (233.6 amps), plus 17 amps, or **250.6** amps. (Step 6 above).

Next, a calculation based on a setting of 22 amps:

1. The Branch Circuit conductor would be 3 times 30, or 90 amps (Step 1 above).
2. The maximum current through the MMP would be 22 amps.
3. The maximum possible motor current to the largest motor would be 90 minus 22, divided by 1.25, or 54.4 amps. (Step 5 above).
4. The branch circuit protective device would be 4 times 54.4 amps (217.6 amps), plus 22 amps, or **239.6** amps. (Step 6 above).

The formula presented in Par. 52A.1.2 of UL 508 was developed from the process above, to determine the maximum size short circuit protective device that can be used in front of group applications. Using that formula on the example:

Amperes = [9.6 x (maximum wire size)] – [2.2 x (minimum motor FLA)]

Where the "maximum wire size" is the ampacity of the maximum size of the wire that will fit in the terminal, and the "minimum motor FLA" is the smallest ampere rating marked on the product (in the case of the MMP, the smallest value on the dial setting.) Using the formula on the example:

Amperes = [9.6 x (30)] – [2.2 x (17)] = **250.6** amps

As can be seen, the UL formula provides the maximum protective device for the range of settings of this MMP.

Table 11. SCPD Size for Group Applications

MMP ① Min. FLA Setting	Max. Wire Size AWG	Max. Wire Size Ampacity	For FLA Minimum Wire Size AWG	Min. Wire Size Ampacity	Max. SCPD Size for Group Applications ② Based on Max. Wire Size			
					For Tap Prot. Max. SCPD Ampacity	Rounded Down Ampacity	For 1/3 Rule Max. SCPD Ampacity	Rounded Down Ampacity
XTPR . . . B:								
0.1	10	30	18	15	300	300	287.758	250
0.16	10	30	18	15	300	300	287.692	250
0.25	10	30	18	15	300	300	287.516	250
0.40	10	30	18	15	300	300	287.01	250
0.63	10	30	18	15	300	300	286.79	250
1	10	30	18	15	300	300	285.58	250
1.6	10	30	18	15	300	300	284.04	250
2.5	10	30	18	15	300	300	281.84	250
4	10	30	18	15	300	300	278.1	250
6.3	10	30	18	15	300	300	272.6	250
8	10	30	18	15	300	300	268.2	250
10	10	30	18	20	300	300	263.8	250
16	10	30	18	30	300	300	257.2	250
20	10	30	18	30	300	300	250.6	250
25	10	30	18	30	300	300	233	225
XTPR . . . D:								
10	2	65	14	20	650	600	599.8	500
16	2	65	14	30	650	600	593.2	500
25	2	65	14	50	650	600	584.4	500
32	2	65	14	50	650	600	575.6	500
40	2	65	14	50	650	600	562.4	500
50	2	65	14	65	650	600	544.8	500
55	2	65	14	65	650	600	536	500

① MMP: Manual Motor Protector.
② SCPD: Short Circuit Protective Device, i.e., circuit breaker or fuses.

Note: The calculation of the maximum SCPD must be made based on the largest possible wire which can be installed in the MMP, since the user is permitted to use a wire larger than is necessary for the FLA.

Table 12. Applications: UL 508 Type E — Self-Protected Combination Motor Controllers ("Type E") Configuration

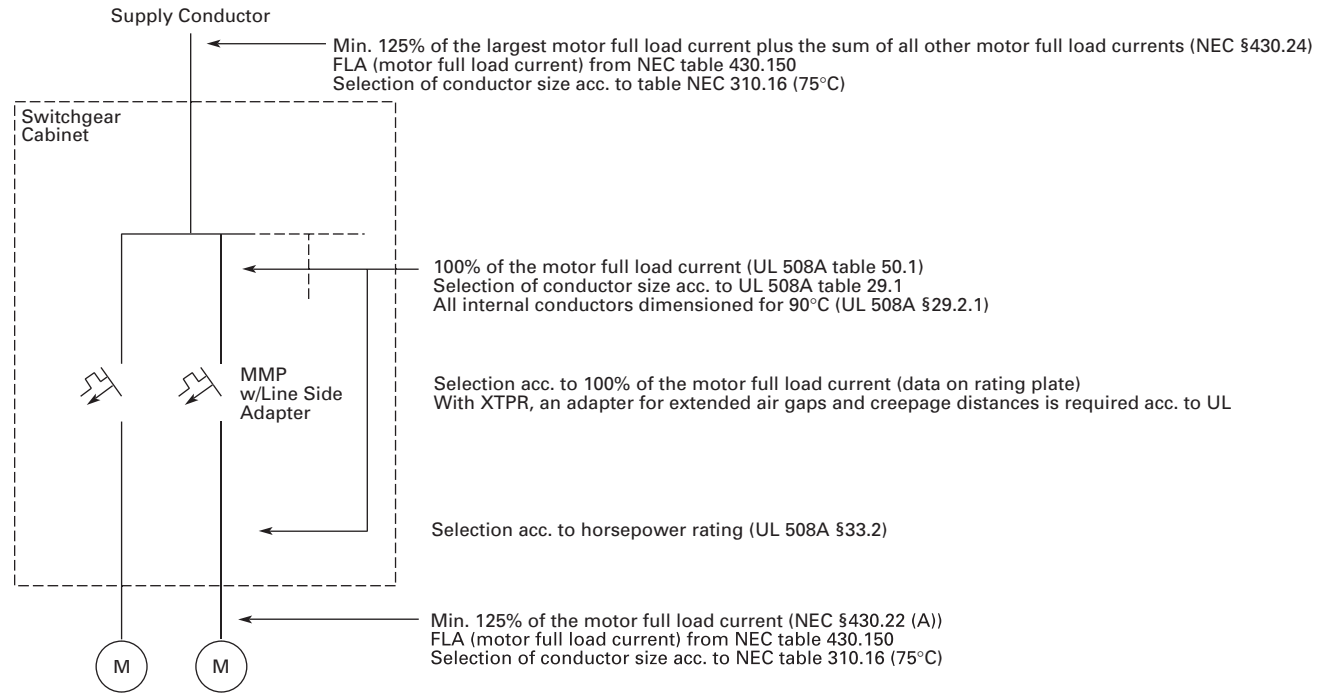


Table 13. NEC Table 430-148 Full-Load Currents in Amperes

Single-Phase Alternating-Current Motors				
hp	**115 Volts**	**200 Volts**	**208 Volts**	**230 Volts**
1/6	4.4	2.5	2.4	2.2
1/4	5.8	3.3	3.2	2.9
1/3	7.2	4.1	4	3.6
1/2	9.8	5.6	5.4	4.9
3/4	13.8	7.9	7.6	6.9
1	16	9.2	8.8	8
1-1/2	20	11.5	11	10
2	24	13.8	13.2	12
3	34	19.6	18.7	17
5	56	32.2	30.8	28
7-1/2	80	46	44	40
10	100	57.5	55	50

The above values of full-load currents are for motors running at usual speeds and motors with normal torque characteristics. Motors built for especially low speeds or high torques may have higher full-load currents, and multi-speed motors will have full-load current varying with speed, in which case the nameplate current ratings shall be used.

The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110V – 120V and 220V – 240V.

Table 14. Adapted from NEC Table 310.16 Allowable Ampacities of Insulated Conductors Rated 0 through 2000 Volts, 60°C through 90°C (140°F through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

Size AWG or kcmil	Temperature Rating of Conductor (See Table 310.13)						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types ①	Types ②	Types ③	Types ①	Types ②	Types ③	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18	—	—	14	—	—	—	—
16	—	—	18	—	—	—	—
14 ④	20	15	15	—	—	—	—
12 ④	25	25	20	20	20	25	12 ④
10 ④	30	35	30	25	30	35	10 ④
8	40	50	55	30	40	45	8
6	55	65	75	40	50	60	6
4	70	85	95	55	65	75	4
3	85	100	110	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	150	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	190	230	255	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	355	420	475	285	340	385	600
700	385	460	520	310	375	420	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	450	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	520	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	560	665	750	470	560	630	2000

① TW and UF.
② RHW, THHW, THW, THWN, XHHW, USE and ZW.
③ TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2 and ZW-2.
④ See 240.4(D).

Correction Factors (Appendix Table 14)

Ambient Temp. °F (°C)	For ambient temperatures other than 30°C (86°F), multiply the allowable Ampacities shown above by the appropriate factor shown below.					
70 – 77 (21 – 25)	1.08	1.05	1.04	1.08	1.05	1.04
78 – 86 (26 – 30)	1.00	1.00	1.00	1.00	1.00	1.00
87 – 95 (31 – 35)	0.91	0.94	0.96	0.91	0.94	0.96
96 – 104 (36 – 40)	0.82	0.88	0.91	0.82	0.88	0.91
105 – 113 (41 – 45)	0.71	0.82	0.87	0.71	0.82	0.87
114 – 122 (46 – 50)	0.58	0.75	0.82	0.58	0.75	0.82
123 – 131 (51 – 55)	0.41	0.67	0.76	0.41	0.67	0.76
132 – 140 (56 – 60)	—	0.58	0.71	—	0.58	0.71
141 – 158 (61 – 70)	—	0.33	0.58	—	0.33	0.58
159 – 176 (71 – 80)	—	—	0.41	—	—	0.41

Table 15. Adapted from NEC Table 430.150 Full Load Current, Three-Phase Alternating-Current Motors

hp	Induction-Type Squirrel Cage and Wound Rotor (Amperes)							Synchronous-Type Unity Power Factor ① (Amperes)			
	115V	200V	208V	230V	460V	575V	2300V	230V	460V	575V	2300V
1/2	4.4	2.5	2.4	2.2	1.1	0.9	—	—	—	—	—
3/4	6.4	3.7	3.5	3.2	1.6	1.3	—	—	—	—	—
1	8.4	4.8	4.6	4.2	2.1	1.7	—	—	—	—	—
1-1/2	12.0	6.9	6.6	6.0	3.0	2.4	—	—	—	—	—
2	13.6	7.8	7.5	6.8	3.4	2.7	—	—	—	—	—
3	—	11.0	10.6	9.6	4.8	3.9	—	—	—	—	—
5	—	17.5	16.7	15.2	7.6	6.1	—	—	—	—	—
7-1/2	—	25.3	24.2	22	11	9	—	—	—	—	—
10	—	32.2	30.8	28	14	11	—	—	—	—	—
15	—	48.3	46.2	42	21	17	—	—	—	—	—
20	—	62.1	59.4	54	27	22	—	—	—	—	—
25	—	78.2	74.8	68	34	27	—	53	26	21	—
30	—	92	88	80	40	32	—	63	32	26	—
40	—	120	114	104	52	41	—	83	41	33	—
50	—	150	143	130	65	52	—	104	52	42	—
60	—	177	169	154	77	62	16	123	61	49	12
75	—	221	211	192	96	77	20	155	78	62	15
100	—	285	273	248	124	99	26	202	101	81	20
125	—	359	343	312	156	125	31	253	126	101	25
150	—	414	396	360	180	144	37	302	151	121	30
200	—	552	528	480	240	192	49	400	201	161	40
250	—	—	—	—	302	242	60	—	—	—	—
300	—	—	—	—	361	289	72	—	—	—	—
350	—	—	—	—	414	336	83	—	—	—	—
400	—	—	—	—	477	382	95	—	—	—	—
450	—	—	—	—	515	412	103	—	—	—	—
500	—	—	—	—	590	472	118	—	—	—	—

① For 90 and 80 percent power factor, the figures shall be multiplied by 1.1 and 1.25, respectively.

The above values of full-load currents are typical for motors running at speeds usual for belted motors and motors with normal torque characteristics.

Motors built for low speeds (1200 rpm or less) or high torques may require more running current, and multispeed motors will have full-load current varying with speed. In these cases, the nameplate current rating shall be used.

The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110V to 120V, 220V to 240V, 440V to 480V, and 550V to 600V.

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