

Application Considerations for UL Combination Starters Class 8538

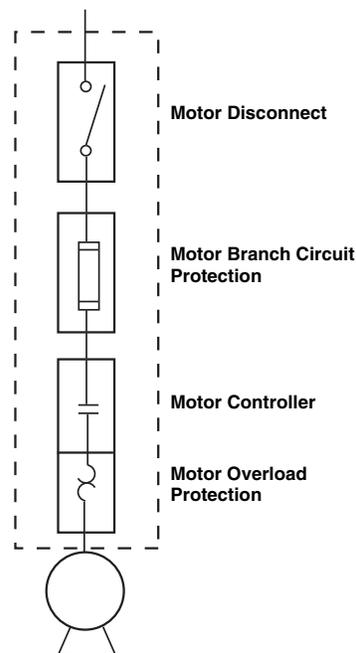
INTRODUCTION

Combination starters are the most common type of packaged motor controllers. They are called combination because of their construction and combined functions. The National Electrical Code (NEC) defines the required functions of combination starters. Underwriters Laboratories, Inc. (UL) specifies the tests and verifications that the components must pass before they can be listed as suitable for use for those functions.

Figure 1 depicts the four component functions that comprise a complete motor branch circuit as defined by the NEC. UL currently recognizes six different styles of combination starters that meet the requirements of a motor branch circuit. This data bulletin discusses the six types of UL recognized combination starters, with an emphasis on UL 508 Type E and Type F classifications. The topics discussed in this paper are:

- Types of combination starter constructions
- Self-protected designation and implications
- Coordination considerations
- Motor control panel design implications

Figure 1: Required Functions of Combination Starters



TYPES OF COMBINATION STARTER CONSTRUCTIONS

UL 508 is the UL safety standard for industrial control equipment. Part IV defines the component functions, construction, testing, and performance requirements of six styles of combination starters. Each of the six styles meets the requirements of NEC Article 430 for the motor disconnecting means, the motor branch-circuit short-circuit and ground fault protection, the motor controller, and the motor overload (OL) protection. Each provides adequate protection against fire or personal injury under fault conditions.

The UL 508 type designations are differentiated by the actual components used to protect the motor branch circuit as illustrated in Table 1.

Table 1: UL Combination Starter Type Designations

	UL Combination Starter Type	Device Used for Component Function			
		Disconnect	Branch Circuit Protection	Motor Controller	Motor OL Relay
Traditional Combination Starters Through 1980s	A	UL 98 Manual Disconnect	UL 248 Fuses	UL 508 Magnetic or Solid State Controller	UL 508 Motor Overload Relay
	B		UL 508 Motor Short Circuit Protector		
	C	UL 489 Inverse Time Circuit Breaker			
	D	UL 489 Instantaneous Trip Circuit Breaker			
Recognized 1990	E	UL 508 Self-Protected Combination Controller			
Recognized 2002	F	UL 508 Manual Self-Protected Combination Controller	UL 508 Magnetic or Solid State Controller	UL 508 Manual Self-Protected Combination Controller	

UL Combination Starters Types A through D

UL 508 Types A through D combination starters are traditional style starters that use either a listed disconnect switch and fuses or a listed circuit breaker as the disconnect means and for short circuit protection. Each type uses a separate UL 508 listed motor controller and overload relay. These starters are evaluated by UL under the same set of short circuit performance tests. Each type clears faults without causing a fire or posing an electrical shock hazard to personnel. Each type is allowed to sustain damage that is contained within enclosures and may require the repair or replacement of devices after performing their protective function.

UL Combination Starter Type E

In the 1980s the concept of a self-protected combination starter was introduced from Europe. This concept introduced an integrated device that performed all the required functions of a combination starter. The first self-protected combination starters were manual, but by the mid-1980s, electro-mechanical self-protected combination starters were also on the market. These starters cleared faults within their rating without sustaining damage and could be put back into operation. UL recognized this concept in 1990 and added the Type E self-protected category for both manual and electro-mechanical combination starters. UL added a separate set of short circuit and endurance performance tests to their 508 standard just for the Type E self-protected category.

UL Combination Starter Type F

Many manufacturers and users started combining a manual UL 508 Type E self-protected starter with a UL 508 contactor and calling the combination "self-protected". This was not an accurate description since the combination had not been tested per the requirements of the UL 508 Type E standard as a combination. UL addressed this by recognizing a Type F category in 2002. This combination starter consisted of the manual self-protected starter and contactor combination. It is evaluated under the same short circuit tests as Types A through D, but it is not considered self-protected.

SELF-PROTECTED DESIGNATION AND IMPLICATIONS

A combination starter must pass certain performance tests specified by UL 508 before it can be designated as self-protected. The required test sequence for the Type E self-protected combination starters is listed in Table 77.4A of UL 508. The test sequence includes both high fault and interrupting ability short circuit (low fault) tests, followed by an endurance test.

The tests required for Types A through D and Type F combination starters are listed in UL 508 Table 77.4. This test sequence does not include the low fault short circuit tests followed by the endurance test. This is the difference between the testing and performance of a Type E self-protected combination starter and the other types.

Type E Interrupting Ability Test

The interrupting ability tests are lower level short-circuit fault tests. These tests simulate the fault levels that a starter could experience in a typical application. The low fault tests range from 3000 to 10,000 available short-circuit amperes for starters rated up to 200 hp, 600 V. This type of fault can be more destructive to the short-circuit protection device than higher short-circuit currents. This is because the magnetic forces are lower, and it may therefore take longer to interrupt the circuit. With the lower circuit interruption, the heat energy (I^2t) could be greater than with higher short circuit currents. Distribution sources with higher available short-circuit currents can also help blow open the contact tips more quickly and possibly reduce the overall damage to the device. This is true for both circuit breakers and fuses.

The low fault tests for wye-connected sources require each pole of the starter to open (clear) a line-to-neutral short circuit applied to a closed pole (contact) and then close into and clear a line-to-neutral short circuit. The starter must also clear a short circuit applied to all three made poles. A Type E combination starter must clear a total of seven short-circuit faults.

Type E Endurance Test

After the interrupting ability short-circuit tests, a Type E combination starter must also pass an endurance test described in UL 508 Table 83.1. The conventional endurance test requires that the starter make and break twice full-load current 1000 times at a duty cycle of 0.5 seconds on and 0.5 seconds off. The starter must then make and break motor full-load current for 5000 operations at a duty cycle of 1 second on and 9 seconds off. Finally, the starter must operate an additional 4000 times at no load. UL 508 specifies that the device must operate without electrical or mechanical breakdown. There can be no welding or excessive pitting of the contact tips.

Implications of Self-Protected Designation

The operational performance demanded by a UL self-protected designation ensures reliability. The starter can experience a fault, clear it, and be put back into operation without operator intervention. This performance decreases the amount of downtime incurred by an installation after a fault, because there is no damage to the motor control equipment. The installation is back into production once the cause of the fault is identified and corrected.

A UL 508 self-protected designation also allows integration of protective functions into a single unit. This designation tests all aspects of a listed combination starter. UL does not specify how to achieve the performance or restrict the design parameters. This allows for one set of power poles to serve as the motor disconnect, short-circuit clearing mechanism, and motor controller. It is possible to have a single device listed as a complete combination starter. This reduces the overall size for a combination motor starter solution.

Type E Marking Requirements

A UL 508 Type E self-protected combination starter must be marked "Self-Protected Combination Motor Controller." UL 508 does allow combinations of devices to be used in a Type E combination starter as long as they pass the performance testing required for the self-protected designation. The most common arrangement on the market today is a manual Type E self-protected combination motor starter used with a contactor. This arrangement can be assembled and shipped as a single unit by the manufacturer or as separate components. However, the assembled unit or separate components must be suitably marked.

- An assembled unit must be marked as a "Self-Protected Combination Motor Controller".
- The manual self-protected combination starter must be marked "Self-Protected Combination Motor Controller when used with (the load side component's manufacturer and part number) or Motor Controllers Marked For Use With This Component".
- The motor controllers must be marked "Suitable For Use On Load Side Of (manufacturer and part number) Manual Self-Protected Combination Motor Controller" when the manual Type E starter makes reference to the marked motor controllers.

The most common mistake made by users is to assume that a manual self-protected combination controller used with a contactor is a UL 508 Type E self-protected combination starter. It is not unless suitably marked as such. The assembly is a UL 508 Type F combination starter when the components are only marked with reference to a "Combination Motor Controller" and not a "Self-Protected Combination Motor Controller". This designation meets the NEC code requirements for a motor branch circuit, but it does not imply or guarantee any better performance than the other UL 508 Types A through D combination starters.

If no reference is made to a self-protected combination starter or combination starter, then the assembly is simply a UL 508 motor controller and motor overload relay. A UL Listed short-circuit protective device and disconnect must also be used with those components to meet the NEC requirements for a motor branch circuit.

COORDINATION CONSIDERATIONS

Effective January 1, 2005 the NEC will require panel builders to list the short-circuit withstand rating of their motor control panels. This requirement is designed to help users properly coordinate their motor control equipment with their distribution system in the event of a fault. In the past, a UL 508A panel did not carry a short-circuit withstand rating and there were no requirements for designers to perform coordinated short-circuit testing. This type of testing requires shorting the conductors at the end of the circuit outside of the enclosure and evaluating the resulting damage. The motor control panel and enclosure combination must limit the damage after interrupting the short circuit as follows:

- A. No expulsion of any debris, fire, or molten metal from the enclosure
- B. Enclosure door/cover must remain closed and must be possible to open

- C. Enclosure must remain intact with little to no cracks or openings
- D. No damage to any conductor or terminal connector
- E. No conductor can be pulled out of its terminal connector
- F. No breakage or cracking of insulating bases of mounted parts to the extent that they fall off the panel or expose live parts

The requirement to list the short-circuit withstand rating means that panel designers must now consider the panel as one coordinated unit. They must use the lowest rated device as their panel's withstand rating unless the devices were tested together for a higher coordinated rating. This creates another problem for the designer in selecting components. The UL minimum short-circuit rating on motor control components for horsepower ratings of 50 hp or below is 5,000 A. The most common motors used are 20 hp or smaller. This means the short-circuit rating of most UL 508A panels installed today would only be 5000 A.

Using a UL 508 Type E or Type F combination starter eliminates the coordination problems of using individual components for the motor branch circuit protection, motor controller, and motor overload relay. The panel builder uses the listed interrupting rating of the combination starter. Most UL 508 Type E or F combination starters on the market today have short-circuit ratings higher than the UL minimums. This makes it easier to list the short-circuit rating and to verify the compatibility of applying a given UL 508A motor control panel on a given distribution system.

Component Selection

The more devices a designer must choose to make a motor control panel, the more opportunity there is for mistakes. UL 508 Type E or Type F combination starters are either a single integrated unit or one in which all components are identified and marked as suitable for use with each other. A designer does not have to go to different sections of the NEC to properly select the motor disconnect, the short-circuit protection device, the motor controller, or the motor overload relay. All necessary components are clearly identified for a particular motor horsepower. This greatly reduces, if not eliminates, the chance of improperly applying a combination starter according to NEC requirements.

MOTOR CONTROL PANEL DESIGN IMPLICATIONS

Group Motor Considerations

Article 430.53 (C) and (D) of the NEC allows a single short-circuit protective device to be used for more than one motor circuit under certain specific conditions. Panel builders use this article to decrease the size and cost of the motor control panel. However, they first have to make sure that the components used are marked and listed for such use.

The components suitable for use in motor group installations can be marked in one of two ways.

1. The motor controller and motor overload relay are both listed as suitable for group installation. An inverse time circuit breaker may be used as the short-circuit protective device if it is also listed as suitable for group installations. The panel designer must then ensure that the short-circuit protective device selected (fuses or inverse time circuit breaker) is not larger than allowed by Article 430.40 for the smallest overload relay used in the circuit. Once these conditions are met, the panel designer can downsize the conductor from the short-circuit protective device to the individual motor controller/overload relay to 1/3 the size of the branch circuit conductor feeding the short-circuit protective device. The designer must limit the motor circuit conductor length from the short-

circuit protective device to the motor controller/overload relay to 25 feet or less.

2. The motor controller and motor overload relay are both listed as suitable for tap conductor protection in group installations. This category allows the designer to downsize the conductor from the short-circuit protective device to the individual motor controller/overload relay to 1/10 the size of the branch circuit conductor feeding the short-circuit protective device. The designer must limit the motor circuit conductor length from the short-circuit protective device to the motor controller/overload relay to 10 feet or less.

In both cases, the feeder taps cannot be less than 125% of the connected motor FLA rating.

Using UL 508 Type E self-protected combination starters or Type F combination starters in group motor installations instead of UL 508 motor controllers and overload relays simplifies group motor considerations for panel designers. Each starter is a fully rated motor branch circuit. The designer follows the same NEC requirements for sizing the feeder conductors as required for single motor branch circuits. The feeder tap conductors can be downsized per Article 430.28. This allows the same flexibility in conductor sizing as offered in Article 430.53 (D) without the component marking and overload relay to short-circuit protective device verification requirements. The UL 508A panel does not need a main short-circuit protective device when each motor controller installed is a combination starter. The upstream short-circuit protective device feeding it protects the panel. The designer only has to consider the enclosure/panel disconnect requirements required by the NEC or local codes.

Panel Packaging Density and Productivity Considerations

Changes in the NEC and UL standards drive changes in motor control panel designs. The additions of the UL 508 Type E self-protected combination starter and Type F combination starter make possible increased panel packaging density and improved panel construction productivity. This is due to the integrated design of the combination starters. Packaging density is improved by eliminating the space between the traditional UL 508 motor controller and the short-circuit protection device that exists with UL 508 Types A through D.

Productivity gains in constructing and servicing the motor control panel are also realized by the integrated design. No wiring is required between:

- The motor disconnect and motor branch circuit protection
- The motor branch circuit protection and motor controller
- The motor controller and motor overload relay

Reduction in wiring saves time and cost in mounting, wiring, and servicing the panel.

SUMMARY

Part IV of UL 508 is the standard governing the construction, testing, and marking of acceptable combination starters that meet the NEC requirements for motor branch circuits. New technology and design concepts offer alternatives to the construction and performance of combination starters. Recent changes in the UL 508 standard recognize these benefits. UL 508 now recognizes six different construction styles and two different performance standards for combination starters.

The UL 508 Type E self-protected combination controller and Type F combination controller are the newest additions to the UL 508 standard. Both offer the following advantages to panel designers:

- Higher coordinated short-circuit withstand ratings on UL 508A panels
- Easier component selection to meet the requirements of group motor applications
- Reduced panel space by reducing the number of components
- Required product markings to help designers quickly and accurately select components
- Increased productivity by reducing the number of wiring connections

UL 508 Type E self-protected combination starters also offer the advantage of reliability. UL 508's special endurance and short-circuit tests ensure a coordinated combination starter that will clear a fault and protect itself from damage. It is the only category of combination starter that a designer can easily identify as self-protected due to the required "Self-Protected Combination Motor Controller" product marking.

REFERENCES

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ISBN 0-7629-0404-6
Industrial Control Equipment
Seventeenth Edition, Dated January 28, 1999

NEC
2002 Edition

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