FAQ

Why is the isolating switch permitted to have integral instantaneous short-circuit overcurrent protection?

Molded case switches are sometimes similar in construction to circuit breakers except for the absence of all tripping elements other than the instantaneous elements. The instantaneous elements that remain provide short-circuit protection only. Most times, the instantaneous elements are the so-called self-protecting "blow-apart" contacts in the device. When enough current flows through the device, the magnetic interaction causes the contacts to begin to open. This causes the normal trip mechanism to activate and finish opening the contacts fully, if the magnetic forces weren't sufficient to do so. These instantaneous (blow-apart) elements in both the isolating switch and circuit breaker also allow the fire pump controller to achieve a higher short-circuit rating than the interrupting capability of the circuit breaker alone. This higher short-circuit rating is accomplished by testing the combination of molded case switch and circuit breaker in a fire pump controller at a high-power short-circuit laboratory. Typically both the isolating switch and the circuit breaker are similar in construction and have similar short-circuit trip currents and opening (clearing) times. When properly designed, both devices open in unison (roughly simultaneously) to clear the fault faster than a single set of contacts in a single device can do.

Note that because of the combination testing, it is important to rely on the rating nameplate short-circuit current rating and not the individual isolating switch or circuit breaker ratings.

10.4.2.2 Externally Operable. The isolating switch shall be externally operable.

Isolating switches must be readily accessible to allow for prompt energizing of the fire pump motor circuit. External operation is necessary to permit nonelectrically qualified personnel to safely energize and de-energize the fire pump controller. With two-handle designs, this is done after the circuit breaker has been de-energized (opened). With single-handle designs, the pump motor and circuit breaker are de-energized nearly simultaneously.

10.4.2.3* Ampere Rating. The ampere rating of the isolating switch shall be at least 115 percent of the full-load current rating of the motor.

A.10.4.2.3 For more information, see *NFPA 70*.

FAQ

How is the ampere rating of the isolating switch determined?

The source of the 115 percent requirement is 430.110 of the *NEC*. This sizing rule accounts for motors running continuously in excess of their rated current because the motor is allowed to draw 115 percent of full-load amperes (FLA) due to the allowance of the motor service factor. See 9.5.2.2(1) for more information.

10.4.2.4 Warning.

10.4.2.4.1 Unless the requirements of 10.4.2.4.2 are met, the following warning shall appear on or immediately adjacent to the isolating switch:

WARNING

DO NOT OPEN OR CLOSE THIS SWITCH WHILE
THE CIRCUIT BREAKER (DISCONNECTING MEANS)
IS IN CLOSED POSITION.

The isolating switch is not required to have a short-circuit interrupting rating. Only the fire pump controller circuit breaker is capable of manually closing on and interrupting a short-circuit current. Attempting to do so with an isolating switch could result in a fire and/or shock hazard. As a result, either the warning label or mechanical interlocking is required to prevent the isolating switch from being either opened or closed unless the circuit breaker is open. The intent is for the circuit breaker to make and break the power path, with the assumption that there is fault current involved, for both personnel safety and equipment protection.

10.4.2.4.2 Instruction Label. The requirements of 10.4.2.4.1 shall not apply where the requirements of 10.4.2.4.2.1 and 10.4.2.4.2.2 are met.

10.4.2.4.2.1 Where the isolating switch and the circuit breaker are so interlocked that the isolating switch can be neither opened nor closed while the circuit breaker is closed, the warning label shall be permitted to be replaced with an instruction label that directs the order of operation.

FAQ

Is the interlocking mechanism for the isolating switch and circuit breaker interlocked with the controller enclosure door? If so, is it provided with a means to circumvent it to allow for testing?

The interlock referenced in 10.4.2.4.2.1 ensures that the circuit breaker, and not the isolating switch, makes and breaks the current flowing in the fire pump power circuit. Most controllers are provided with interlocking mechanisms having either one or two operating handles. In most cases, the isolating switch operating handle mechanism has a two-way interlock with the enclosure door. The interlocking means is also provided with a means to circumvent the interlock to allow for testing and maintenance with the controller energized.

10.4.2.4.2.2 This label shall be permitted to be part of the label required by 10.3.7.3.

10.4.2.5 Operating Handle.

10.4.2.5.1 Unless the requirements of 10.4.2.5.2 are met, the isolating switch operating handle shall be provided with a spring latch that shall be so arranged that it requires the use of the other hand to hold the latch released in order to permit opening or closing of the switch.

The use of a spring latch requires a two-hand operation to close or open the isolating switch. This safety feature minimizes inadvertent opening or closing of the switch. Instructions for operating the latch are normally included with the warning marking required in 10.4.2.4.1. See Exhibit I.10.3.

10.4.2.5.2 The requirements of 10.4.2.5.1 shall not apply where the isolating switch and the circuit breaker are so interlocked that the isolating switch can be neither opened nor closed while the circuit breaker is closed.

10.4.3 Circuit Breaker (Disconnecting Means).

10.4.3.1* General. The motor branch circuit shall be protected by a circuit breaker that shall be connected directly to the load side of the isolating switch and shall have one pole for each ungrounded circuit conductor.

FAQ

What types of circuit breakers are acceptable in a fire pump controller?

At one time there were separately listed circuit breakers by General Electric, Westinghouse, and ITE (now part of Siemens), but they have not been offered for several decades. All circuit breakers in modern controllers consist of an instantaneous-only circuit breaker or "motor circuit protector," or a self-protected molded case switch, all of which contain a shunt trip coil (solenoid) controlled by current-sensing circuitry fed by three current transformers (CTs).

A.10.4.3.1 For more information, see *NFPA 70*, Article 100.

10.4.3.2 Mechanical Characteristics. The circuit breaker shall have the following mechanical characteristics:

(1) It shall be externally operable. *(See 10.3.6.)*
(2) It shall trip free of the handle.

FAQ

What does "trip free of the handle" mean?

The term *trip free* means that on sensing a high enough current for long enough, the circuit breaker acts to interrupt the circuit, even if the handle is locked in the ON position. Tripping free can occur in fire pump controllers by way of the external handle and operator mechanism. Modern self-protecting isolating switches also have the ability to trip free.

(3) A nameplate with the legend "Circuit breaker — disconnecting means" in letters not less than ⅜ in. (10 mm) high shall be located on the outside of the controller enclosure adjacent to the means for operating the circuit breaker.

10.4.3.3* Electrical Characteristics.

A.10.4.3.3 Attention should be given to the type of service grounding to establish circuit breaker interrupting rating based on grounding type employed.

The service grounding described in A.10.4.3.3 is usually the neutral of a 4-wire wye system, such as a 208/120 V ac or a 480/277 V ac system. However, it can also be one side of 120/240/208 V ac 4-wire corner grounded delta system, which were once common and are still widely used. Corner ground and ungrounded delta at 240 V ac or 480 V ac are also possible.

The controller must be compatible with the system voltage and method of system grounding.

10.4.3.3.1 The circuit breaker shall have the following electrical characteristics:

(1) A continuous current rating not less than 115 percent of the rated full-load current of the motor

FAQ

How is the ampere rating of the circuit breaker determined?

The ampere rating of the circuit breaker is on the listing label of the circuit breaker. It is usually also marked on the toggle handle of the breaker. The full-load amperes (FLA) of the motor is determined by 430.110 of the *NEC*. This sizing rule accounts for motors running continuously in excess of their rated horsepower by up to 115 percent (1.15 service factor). This requirement is also applied to the isolating switch in 10.4.2.3.

(2) Overcurrent-sensing elements of the nonthermal type

This requirement was added as a result of older construction methods for a brand of fire pump controllers that used thermal sensing elements for measuring and timing the tripping of the circuit breaker. Modern controllers use a combination of current transformers, electronic analog and/or digital circuitry, and a shunt trip coil (solenoid) in the circuit breaker. Compliance with this requirement results in the breaker being capable of being reset immediately (without delay). If the circuit breaker trips while the pump motor is running under fire conditions, resetting the circuit breaker to try to put the motor back into service should be accomplished without waiting.

FAQ

Why is a thermal magnetic circuit breaker not allowed to provide overcurrent protection for the fire pump motor?

Thermal magnetic breakers also contain thermal elements that require a cooling time before they can be reset. Hence, they would always violate the requirement in 10.4.3.3.1(2), and, therefore, cannot be used.

(3) Instantaneous short-circuit overcurrent protection

This characteristic is vital, fundamental, and the most important aspect of the short-circuit current rating (SCCR) of the controller. The opening time for the circuit breaker, and also for many designs for the isolating switch, determines how much short-circuit current the controller will be exposed to and for how long.

(4) An adequate interrupting rating to provide the suitability rating of the controller discussed in 10.1.2.2

FAQ

How can the interrupting rating (AIC) of the circuit breaker be less than the short-circuit rating of the fire pump controller?

Generally, the higher the interrupting rating (AIC) of the circuit breaker, the higher the short-circuit rating of the controller can be. However, the two ratings should never be confused or used interchangeably because the short-circuit rating must be established by high-power short-circuit laboratory-type (prototype) testing of a number of sample controllers of different horsepower and/or different voltage ratings. The actual controller short-circuit rating can be either a smaller or higher number than the circuit breaker AIC rating value. It can be higher when the isolating switch is also of the self-protecting type.

(5) Capability of allowing normal and emergency starting and running of the motor without tripping *(see 10.5.3.2)*

Fire pump motors exhibit high in-rush currents under starting conditions. For a Code G motor these currents are approximately 6 times the full-load amperes (FLA) (see Table 430.7(B) of the *NEC*). It is important that these in-rush currents do not cause tripping of the circuit breaker. This is especially important on power supply circuits having a high X to R (X/R) ratio, meaning circuits that are more inductive, as is typical of higher horsepower installations. In the first half-cycle, these in-rush starting currents can be twice the locked rotor currents. See Tables 9.5.1.1(a), 9.5.1.1(b), or 9.5.1.1(c) for maximum locked rotor currents allowed. For a typical Code G motor, the first half-cycle current can be approximately 12 times motor FLA. Some controllers have no fewer than 13 times instant trip ratings on all three poles of the circuit breaker for this reason. The reference to 10.5.3.2 means that all controllers are started in the full voltage across-the-line (ATL) or direct-on-line (DOL) mode when the emergency-run mechanical operator is used to start the fire pump. Even higher transient currents can occur with open transition wye-delta starting, depending on the fire pump controller design.

(6) An instantaneous trip setting of not more than 20 times the full-load current

FAQ

Why is the instantaneous trip setting of the fire pump breaker allowed to be a maximum of 20 times the motor full-load current?

The limit of 20 times for the instantaneous trip setting of the fire pump breaker was increased from the value allowed in Article 430 of the *NEC* for ordinary motor branch circuits. This was done to allow higher settings in fire pump controllers to reduce the likelihood of the circuit breaker tripping under motor starting conditions with open transition wye-delta starting. The open transition can cause transients up to 17 times the motor full-load amperes (FLA) value. For this reason, closed transition starting is always the best practice.

Some controllers delay the wye-delta open transition for one or more seconds, which loses most of the motor RPM speed and results in across-the-line (ATL) [direct-on-line (DOL)] currents after the transition to full-voltage (delta) running. Some controllers control the transition by way of a lead-lag monitor to keep the transient (spike) currents within acceptable limits. Some designs increase the size of the isolating switch and circuit breaker to ensure that the instantaneous trip currents are 20 times the motor's rated FLA current. This provides adequate tolerance of starting surge currents (first-half cycle offset currents), especially in systems with high X/R ratios, as is normally the case with large (high horsepower) motor circuits.

A.10.4.3.3.1(4) The interrupting rating can be less than the suitability rating where other devices within the controller assist in the current-interrupting process.

See the FAQ regarding combination testing after 10.4.2.1.3.

10.4.3.3.1.1* The circuit breaker shall not trip when starting a motor from rest in the across-the-line (direct-on-line) mode, whether or not the controller is of the reduced inrush starting type.

All controllers have an emergency run mechanical operator as required in 10.5.3.2. This causes full-voltage across-the-line (ATL) or direct-on-line (DOL) starting regardless of the type of reduced voltage starting.

A.10.4.3.3.1.1 The isolating switch is not allowed to trip either. See also 10.4.2.1.3.

This requirement clarifies that the isolating switch also needs to allow full-voltage starting without tripping.

10.4.3.3.1.2* The circuit breaker shall not trip when power is interrupted from a running pump, or if the pump is restarted in less than 3 seconds after being shut down. If a control circuit preventing a re-start within 3 seconds is provided, this requirement shall not apply.

A.10.4.3.3.1.2 See also A.10.4.3.3.1.1.

This requirement clarifies that the circuit breaker should not trip when the motor stops and immediately restarts, such as after the automatic stop (minimum run) timer times out while a pump demand still exists. This is usually the case when there is a small demand, such as when a few sprinkler heads are open and controlling a fire. The pump discharge pressure will usually be high enough to reset the pressure switch or sensor, which allows the automatic stop timer to stop the pump. When the pressure drops back below the pump start value, the controller will immediately restart the motor. For controllers lacking a restart delay provision, the motor will have some amount of back electromagnetic field (EMF), which will be out of phase and not the same frequency as the line voltage. The result could be a restart transient as high as 24 times the motor full-load amperes (FLA value). Adding a 3- second restart delay allows the motor back EMF to dissipate so a normal start can be made. The motor will still be spinning after 3 seconds, but the back EMF will be gone.

10.4.3.3.2* Current limiters, where integral parts of the circuit breaker, shall be permitted to be used to obtain the required interrupting rating, provided all the following requirements are met:

(1) The breaker shall accept current limiters of only one rating.
(2) The current limiters shall hold 300 percent of full-load motor current for a minimum of 30 minutes.
(3) The current limiters, where installed in the breaker, shall not open at locked rotor current.
(4) A spare set of current limiters of correct rating shall be kept readily available in a compartment or rack within the controller enclosure.

FAQ

Why are current limiters allowed when fuses may not be used to provide overload protection in the fire pump controller?

Current limiters are intended to provide short-circuit protection only, so they must not open under any conditions of motor overload covered in 10.4.4(1)(a) and (b).

A.10.4.3.3.2 Current limiters are melting link-type devices that, where used as an integral part of a circuit breaker, limit the current during a short circuit to within the interrupting capacity of the circuit breaker.

10.4.4 Locked Rotor Overcurrent Protection. The only other overcurrent protective device that shall be required and permitted between the isolating switch and the fire pump motor shall be located within the fire pump controller and shall possess the following characteristics:

In fire pump controllers, the motor overload protection means are the same as the overcurrent elements — namely, the current transformers, the sensing circuitry, and the shunt trip coil (solenoid) in the circuit breaker. Separate overload relays are prohibited under 10.4.4(5). This reduces the number of elements in the critical starting and running path of the fire pump motor, which serves to increase reliability.

(1) For a squirrel-cage or wound-rotor induction motor, the device shall be of the time-delay type having tripping times as follows:

This requirement sets the time and current values for the motor overload protection. Traditionally, this function has been an "inverse time" or reciprocal curve. With the values defined in 10.4.4(1)(a) and (b), the curve is defined and can be drawn — within limits. This reciprocal characteristic best suits protecting a motor because it is similar in nature to the motor heating curve. This provides the best protection of the motor consistent with not over protecting it at the expense of stopping a running fire pump providing fire water.

(a) Between 8 seconds and 20 seconds at locked rotor current

The 8 to 20 seconds is longer than most combination motor starters, which will generally trip in 10 seconds or less. However, the intent is to keep the starting torque applied long enough to break away a stuck or seized pump. The motor might be warm at the end of this time but not destroyed or inoperable.

(b) Three minutes at a minimum of 300 percent of motor full-load current

Subsection 10.4.4(1)(b) used to read "(b) Calibrated and set at a minimum of 300 percent of motor full-load current." This meant that the circuit breaker timing circuit would not begin its timing means unless the current was above 300 percent of motor full-load amperes (FLA). This allowed a running motor to continue running if one of the three phases was lost. Note that the actual "pick-up" (timing start) current is higher than 300 percent, the minimum value.

The requirement was changed for the 2013 edition to make testing and verification easier because 3 minutes should normally be long enough to verify that the electronic sensing circuitry has not started timing and is not likely to trip the circuit breaker.

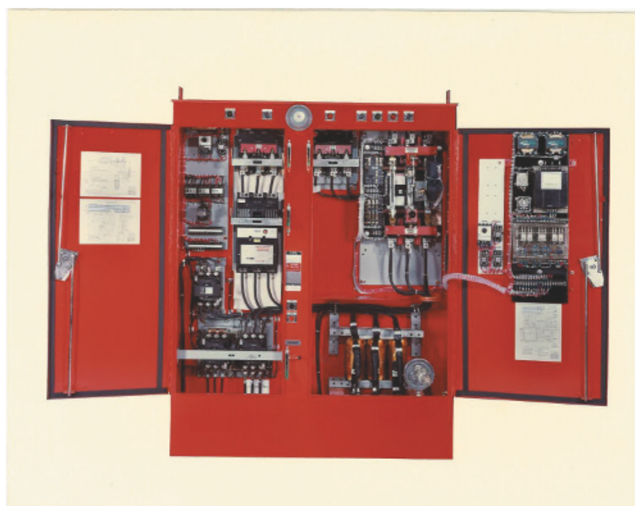
(2) For a direct-current motor, the device shall be as follows:
   (a) Of the instantaneous type
   (b) Calibrated and set at a minimum of 400 percent of motor full-load current

The requirements in 10.4.4(2) address a time period when dc motors were commonly used for fire pumps. See the commentary to 9.5.1.2 for more on this.

(3) There shall be visual means or markings clearly indicated on the device that proper settings have been made.

The visual means referred to here are intended to clearly indicate the motor full-load amperes (FLA) value to which the breaker is set. It could be a dial or a display screen menu item. See Exhibit I.10.12.

EXHIBIT I.10.12 *Fire Pump Controller. (Courtesy of Master Control Systems, Inc.)*



(4)* It shall be possible to reset the device for operation immediately after tripping, with the tripping characteristics thereafter remaining unchanged.

(5) Tripping shall be accomplished by opening the circuit breaker, which shall be of the external manual reset type.

A.10.4.4(4) It is recommended that the locked rotor overcurrent device not be reset more than two consecutive times if tripped due to a locked rotor condition without the motor first being inspected for excessive heating and to alleviate or eliminate the cause preventing the motor from attaining proper speed.

Motors subjected to more than two consecutive starts under locked rotor conditions could incur damage that would affect the motor's performance or render it inoperable.

FAQ

Why is the 300 percent requirement for 3 minutes allowed since motor and wire insulation damage will occur by the time the breaker trips?

A three-phase motor is not capable of starting under a single-phase condition, but it can continue to run if the single-phase condition occurs while the motor is running. If the motor is only partially loaded under this condition, the motor will continue to run for a long time. However, if the motor is fully loaded, the currents will be approximately 200 percent. The 300 percent requirement allows the fire pump to continue to run and provide fire-fighting water under this distressed condition. The fire pump supply circuit, motor, and controller are designed to be sacrificial during a fire so the fire pump is allowed to continue to run until electrical failure occurs.

10.4.5 Motor Starting Circuitry.

10.4.5.1 Motor Contactor. The motor contactor shall be horsepower rated and shall be of the magnetic type with a contact in each ungrounded conductor.

FAQ

Don't all contactors have a contact in each line conductor?

The code requires three contacts for three-phase controllers for safety reasons. There are some designs that utilize two-pole contactors for three-phase circuits. While this works on a functional basis, it leaves the motor windings electrically live all the time because one phase is tied directly to the voltage source.

10.4.5.1.1 Running contactors shall be sized for both the locked rotor currents and the continuous running currents encountered.

With across-the-line (ATL) [direct-on-line (DOL)] starting, the running current is the motor service factor amperes (SFA) (FLA × the maximum 1.15 service factor), while the starting current is calculated to be at locked rotor amperes (LRA) (600 percent of FLA). With part winding starting, however, while the two contactors carry only half of the SFA current, the contactor that does the starting carries 65 percent of the motor FLA. So, two 50 hp contactors would not be large enough for a 100 hp part winding controller due to the starting current. Some contactors are in the circuit only during starting — such as in primary reactor, primary resistor, soft starting, or autotransformer starting — and those contactors must be sized for the starting current, as must the wye contactor with wye-delta and autotransformer starting.

10.4.5.1.2 Starting contactors shall be sized for both the locked rotor current and the acceleration (starting) encountered.

The sizing criteria for the selection of running and starting contactors in a fire pump controller are provided in 10.4.5.1.1 and 10.4.5.1.2. Across-the-line (ATL) starting fire pump controllers generally employ one contactor that meets the sizing criteria specified for a running contactor. Reduced-voltage starting fire pump controllers employ multiple contactors, and the sizing criteria that an individual contactor needs to meet is based on its function in the controller.

10.4.5.2 Timed Acceleration.

10.4.5.2.1 For electrical operation of reduced-voltage controllers, timed automatic acceleration of the motor shall be provided.

10.4.5.2.2 The period of motor acceleration shall not exceed 10 seconds.

The requirement in 10.4.5.2.2 ensures that the pump is running at full speed within 10 seconds of the signal to start.

10.4.5.3 Starting Resistors. Starting resistors shall be designed to permit one 5-second starting operation every 80 seconds for a period of not less than 1 hour.

Starting resistors that are not sized based on duty cycle are subject to overheating and burnout. Duty cycle in this context is the proportion of time during which the motor-starting resistor is dissipating its maximum rated power. Duty cycle can be expressed as a ratio or as a percentage. The higher the duty cycle, the shorter the resistor's useful life, if all other things are equal. To reduce costs, the resistors are allowed to use a 5-second start cycle rather than the usual 10. Also, a substantial cooling time of 80 seconds is required because these resistors typically get very hot after use.

10.4.5.4 Starting Reactors and Autotransformers.

10.4.5.4.1 Starting reactors and autotransformers shall comply with the requirements of ANSI/UL 508, *Standard for Industrial Control Equipment*, Table 92.1.

10.4.5.4.2 Starting reactors and autotransformers over 200 hp shall be permitted to be designed to Part 3 of ANSI/UL 508, *Standard for Industrial Control Equipment*, Table 92.1, in lieu of Part 4.

Starting reactors and autotransformers over 200 hp are not required to meet the more stringent performance criteria of ANSI/UL 508, *Standard for Industrial Control Equipment,* Table 92.1, Part 4, because of the requirement in 10.4.5.2.2 limiting motor acceleration time. The criteria in Part 4 of ANSI/UL 508 include a higher duty cycle. In any case, the reactors and autotransformers easily handle multiple 10-second start cycles, although a 3-second start cycle is normally enough to get the motor up to full speed, due to the high torque delivered by these two starting methods.

10.4.5.5 Soft Start Units.

10.4.5.5.1 Soft start units shall be horsepower rated or specifically designed for the service.

FAQ

Do soft start units for fire pump service need to be rated in horsepower?

Soft start units can be rated in amperes as long as the rating is at least equivalent to the motor full-load current.

10.4.5.5.2 The bypass contactor shall comply with 10.4.5.1.

The bypass contactor must comply with 10.4.5.1 and its subsection 10.4.5.1.1 because it is a running contactor. This contactor is energized after the accelerate time (usually 10 seconds) to bypass the soft start unit, which helps avoid the heat buildup that would otherwise occur if the soft start unit ran the motor continuously. For example, a 60 hp, 208 V ac unit would dissipate approximately 500 watts without the bypass contactor.

The starting contactor must comply with 10.4.5.1.2. Note that the start contactor is kept energized with designs that provide a soft start function. However, no substantial current flows through this contactor when the bypass contactor closes. For the ramp-down (soft stop) function, the controller de-energizes the bypass contactor, causing motor current to flow through the soft start unit again. The controller also signals the soft starter to ramp down the motor voltage, normally over a 10-second period. At the end of this time, the controller also de-energizes the start contactor. Some designs allow the pump to coast to a stop and some designs employ an additional isolating contactor that keeps the soft starter unit off-line and immune to line voltage transients during the standby periods.

10.4.5.5.3 Soft start units shall comply with the duty cycle requirements in accordance with 10.4.5.4.1 and 10.4.5.4.2.

FAQ

Are soft start units considered to be reduced voltage starting controllers?

Soft start units are categorized as reduced voltage starting controllers that are similar to resistor, reactor, and autotransformer controllers and so must meet the same performance criteria as these controllers. They are often specified for hydraulic reasons. They gradually ramp up motor voltage over a 10-second start cycle, which reduces the water surge that can otherwise occur, especially when the system pressure has dropped significantly or when the water demand is large. Most controllers also ramp down the motor speed prior to shutting down the motor. This reduces the sudden pressure fall-off and can greatly reduce the banging of the main check valve, especially in high-rise applications. Note that the acceleration and ramp-down are factory set (nonadjustable) with many of these types of controllers.

10.4.5.6 Operating Coils.

N **10.4.5.6.1** For controllers of 500 V or less, the operating coil(s) for any motor contactor(s) and any bypass contactor(s), if provided, shall be supplied directly from the main power voltage and not through a transformer.

N **10.4.5.6.2** For controllers rated above 500 V but not more than 600 V, a transformer shall be permitted to supply the operating coils referred to in 10.4.5.6.1.

FAQ

Why is the operating coil for the motor contactor not allowed to be supplied through a transformer?

Supplying the operating coil directly from the main power voltage maximizes the reliability of contactor operation because it also reduces the number of items in the critical starting path. Also, if a transformer is used to supply the coil (or coils in reduced voltage controllers), it would have to be substantial in size. Coils are easily available at 460 V and less, but 575 V coils can be difficult to find immediately in stock. The tradeoff between maximum reliability and immediate availability is now permitted for controllers over 500 V.

10.4.5.7* Single-Phase Sensors in Controller.

Single-phase sensors detect when one of the legs (lines) of a three-phase power source is lost or open. Some controllers provide single-phase start protection for all three single-phasing conditions. Paragraph 10.4.5.7 governs this function. Note, however, that all controllers inherently provide single-phase start protection when either of the two legs providing control power is lost. This is because, regardless of the state of the control circuitry, the motor contactor(s) cannot pick up (close) if control power is lost.

A.10.4.5.7 The signal should incorporate local visible indication and contacts for remote indication. The signal can be incorporated as part of the power available indication and loss of phase signal. *(See 10.4.6.1 and 10.4.7.2.2.)*

This is the normal means by which a motor running under single-phase conditions uses the power failure (phase loss) contacts to signal the remote indication (such as an alarm set). The result will be the simultaneous occurrence of both a motor running and a power failure indication.

10.4.5.7.1 Sensors shall be permitted to prevent a three-phase motor from starting under single-phase condition.

Three-phase motors at rest cannot be started with single-phase power. All three phases are needed to create the rotating magnetic vector needed to get a standing motor rotor to develop enough torque to turn the motor shaft. Trying to do so can cause damage to or destruction of the motor windings and often to the controller as well.

10.4.5.7.2 Such sensors shall not cause disconnection of the motor if it is running at the time of single-phase occurrence.

A motor running at or near full speed (above the breakdown speed) can continue to run if one of the three legs is lost due to an open circuit. It will draw between 173 percent and 200 percent more current than it did when it was running under three-phase power. If the motor was running under light load and drawing less than 57 percent of full-load amperes (FLA) (115%/2), it can run continuously with only a slight drop in running speed. The winding current will still be less than 115 percent of rated motor FLA and will not overheat the windings. This is the usual case when fighting a fire; normally, only a few heads are open then. Most motors at full load or into their service factor can still run at close to normal speed, if the voltage doesn't drop too far. They will draw up to 230 percent of FLA (115% × 2) and eventually overheat the windings until the motor fails. This will take some time but will provide fire water until the motor runs to destruction.

10.4.5.7.3 Such sensors shall be monitored to provide a local visible signal in the event of malfunction of the sensors.

This requirement addresses the possibility that, when there is full three-phase power, false detection of a single-phase event will prevent a motor from starting when needed.

10.4.5.8 No ground fault protection (tripping) shall be allowed.

10.4.5.9 A ground fault alarm shall be permitted.

While 10.4.5.9 permits the use of an alarm to sound when a ground fault occurs, tripping is not permitted by 10.4.5.8.

10.4.6* Signal Devices on Controller.

Subsections 10.4.6 and 10.4.7 indicate which functions need to be monitored in fire pump controllers and fire pump power transfer switches. Some controllers also include a single-phase alarm and a motor overload alarm. The former is valuable to indicate that there is a demand for the fire pump, but the pump won't start due to a single-phase condition or that it is running in a single-phase condition that will overload the motor. The latter is important because the controller will run the motor to destruction, and this alarm warns of an impending failure. If the pump is not fighting a fire, the overload alarm provides notification that the pump is in danger of being damaged. If the pump is fighting a fire, the alarm indicates impending failure of the motor. In either case, the alarm should provide a warning to determine the motor current.