UNIT
7

MOTOR, AIR-CONDITIONING, AND TRANSFORMER CALCULATIONS

Introduction to Unit 7—Motor, Air-Conditioning, and Transformer Calculations

Motors and Air-Conditioning. Motor circuits have special requirements that effect how the overcurrent protective device is sized and installed. Motors typically draw about six times as much current at start-up as they draw during normal operation. Article 430 provides guidance on how to properly protect a motor from overcurrent and still avoid nuisance tripping of the fuse or circuit breaker protecting it. Similar rules are included in Article 440 for air conditioners. Careful study of this unit will help you understand the sometimes-confusing requirements of these two articles.

Transformers. Transformers are essential to electric power distribution. They're at the very core of our ability to manipulate alternating-current voltage allowing for the transmission, distribution, and use of electrical power. It's essential for you to understand transformers, their capabilities, and how they interact with electricity.

If you remove the cover of a single-phase transformer and look inside, you'll see two sets of windings; and you'll immediately understand why they're called "windings." The manufacturer literally winds wire into a coil. Those windings are used to raise or lower the voltage to the voltage needed for the connected equipment. One example would be a 480V transformer that "steps down" the secondary voltage to 120V for receptacles in offices or wherever else 120V of power needs to be supplied.

We'll conclude this unit by discussing the bonding and grounding of transformers. This is an area where mistakes are common.

7.13 Adjustable-Speed Drives

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Adjustable-speed drives can be variable-frequency speed drives (VFDs)—which refer to alternating-current drives only, or variable-speed drives (VSDs) which can be alternating-current or direct-current drives. VFDs vary the speed of an alternating-current motor by varying the frequency to the motor. VSDs, when applied to direct-current motors, vary the speed by varying the voltage to the motor.

Branch-Circuit and Feeder Conductor Sizing for Adjustable-Speed Drives [430.122]

(A) Branch-Circuit Conductors. Circuit conductors for an adjustable-speed drive system must have an ampacity of not less than 125 percent of the rated input current of the adjustable-speed drive system. ▸Figure 7–58

Adjustable-Speed Drive, Input Conductor Size *430.122(A)*

Conductors supplying an adjustable-speed drive system must have an ampacity of not less than 125% of the rated input current of the adjustable-speed drive system.

▸Figure 7–58

▶ Motor Branch-Circuit for Adjustable-Speed Drive System Example

Question: *What size branch-circuit conductors are required for an adjustable-speed drive system with a rated input of 25A and terminals rated 75°C?* ▶Figure 7–59

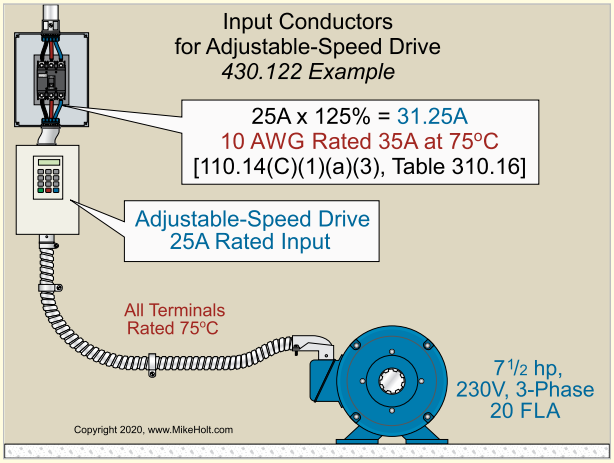
(a) 14 AWG (b) 12 AWG (c) 10 AWG (d) 8 AWG

Solution:

Rated Input from Adjustable-Speed Drive = 25A

Branch-Circuit Conductor = 25A × 125%
Branch-Circuit Conductor = 31.25A

Use 10 AWG rated 35A at 75°C [Table 310.16 and 110.14(C)(1)(a)(3)].



▶Figure 7–59

Answer: *(c) 10 AWG*

Note 1: Adjustable-speed drive systems can have multiple power ratings and corresponding input currents.

Note 2: Circuit conductors on the output of an adjustable-speed drive system are susceptible to breakdown under certain conditions due to the characteristics of the output waveform of the drive. Factors affecting the conductors include (but aren't limited to) the output voltage, the frequency and current, the length of the conductors, the spacing between the conductors, and the dielectric strength of the conductor insulation. Methods to mitigate breakdown include consideration of one or more of these factors.

(B) Output Conductors. The conductors between the adjustable speed drive equipment and the motor must have an ampacity not less than 125 percent of the motor's full-load current (FLC) as listed in Tables 430.248 and 430.250.

Ex: If the adjustable speed drive equipment is listed and marked as "Suitable for Output Motor Conductor Protection," the conductor between the adjustable speed drive equipment and the motor must have an ampacity not less than the larger of:

(1) 125 percent of the motor's full-load current (FLC) as listed in Tables 430.248 and 430.250

(2) The ampacity of the minimum conductor size marked on the adjustable speed drive equipment

Note: The minimum ampacity required of output conductors is often different than that of the conductors supplying the adjustable speed drive equipment. See 430.130 and 430.131 for branch-circuit protection requirements.

(D) Several Motors or a Motor and Other Loads. Conductors supplying several motors or a motor and other loads (including adjustable speed drive equipment), must have ampacity in accordance with 430.24, using the rated input current of the adjustable speed drive equipment for purposes of calculating ampacity.

Author's Comment:

- 430.24 requires the ampacity of the feeder conductors to be the sum of 125 percent of the highest rated motor load or the adjustable speed drive equipment (drive) rated input current, the sum of the remaining full-load motor current (drive input current), 100 percent of the noncontinuous nonmotor loads, and 125 percent of the continuous nonmotor loads.

Branch-Circuit Protection for Adjustable-Speed Drives [430.130]

(A) Circuits Containing an Adjustable-Speed Drive System. Circuits containing adjustable speed drive equipment must be protected by a branch-circuit short-circuit and ground-fault protective device in accordance with all of the following:

(1) The rating and type of protection must be determined by 430.52(C)(1), (C)(3), (C)(5), or (C)(6) using the motor's full-load current (FLC) rating as listed in Tables 430.248 and 430.250.

Ex: The rating and type of protection is determined by Table 430.52 using the adjustable speed drive equipment's rated input current where the adjustable speed drive equipment is listed and marked "Suitable for Output Motor Conductor Protection."

Note 1: Motor conductor branch-circuit short-circuit and ground-fault protection from the adjustable speed drive equipment to the motor is provided by adjustable speed drive equipment that's listed and marked "Suitable for Output Motor Conductor Protection."

Note 2: A motor branch circuit using adjustable speed drive equipment, including equipment listed and marked "Suitable for Output Motor Conductor Protection," includes the input circuit to the adjustable speed drive equipment.

(2) The maximum branch-circuit short-circuit and ground-fault protective ratings must be in accordance with the manufacturer's instructions.