Part X. Adjustable-Speed Drive Systems

430.120 General. The installation requirements for Part I through Part IX are applicable unless modified or supplemented by Part X.

Power conversion equipment used in adjustable-speed drive systems shall comply with Part X for an input or output rated 1000 volts or lower and with Part XI for an input or output rated over 1000 volts.

Adjustable-speed drives are used extensively in commercial, institutional, and industrial motor applications. Exhibit 430.22 shows 480-volt adjustable-speed drives, also known as variable-frequency drives (VFDs).

Part X consolidates requirements that are unique to these drives, which include rules regarding methods of overtemperature protection in motors (see 430.126). This is a critical area, because motors operating at reduced speed do not provide adequate air circulation over windings from a fan integral with the motor. An overload device that actuates on current exceeding full-load amperes will not operate, because the operating current at slower speeds is reduced. A thermal-sensing device integral with the motor will sense a temperature rise in the motor windings.

430.122 Conductors — Minimum Size and Ampacity.

Δ **(A) Branch/Feeder Circuit Conductors.** Circuit conductors supplying power conversion equipment included as part of an adjustable-speed drive system shall have an ampacity not less than 125 percent of the rated input current to the power conversion equipment.

Informational Note: Power conversion equipment can have multiple power ratings and corresponding input currents.

Δ **(B) Output Conductors.** The conductors between the power conversion equipment and the motor shall have an ampacity equal to or larger than 125 percent of the motor full-load current as determined by 430.6(A) or (B).

Exception: If the power conversion equipment is listed and marked as "Suitable for Output Motor Conductor Protection," the conductor between the power conversion equipment and the motor shall have an ampacity equal to or greater than the larger of the following:

(1) 125 percent of the motor full-load current as determined by 430.6(A) or (B)
(2) The ampacity of the minimum conductor size marked on the power conversion equipment

Informational Note No. 1: See 430.130 and 430.131 for branch circuit protection requirements. The minimum ampacity required of output conductors is often different than that of the conductors supplying the power conversion equipment.

Informational Note No. 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 are not limited to, the output voltage, 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.

Where an adjustable-speed drive system is used in a motor circuit, two sets of branch-circuit conductors must be considered in respect to minimum size. The basis for sizing the branch-circuit conductors supplying the power conversion equipment is the input current rating of that unit. That portion of the branch circuit from the power conversion equipment to the motor (i.e., output conductors) uses the general motor branch-circuit approach, and the currents found in the Article 430 tables are the basis used for sizing. Both the input conductors and the output conductors are required to be sized by applying 125 percent to the conductor sizing parameter specified in 430.122(A) and (B).

EXHIBIT 430.22 Adjustable-speed drives for air-handling units provide significant power savings for fan appliances. *(Courtesy of International Association of Electrical Inspectors)*

Calculation Example

Given a power conversion unit to be used with a 10-hp, 480-volt, 3-phase squirrel-cage motor driving an exhaust fan, find the minimum size copper conductors to supply the input of the drive and to run from the output of the drive to the motor.

Solution

Step 1: Input Conductors. The input conductors supplying the power conversion equipment are based on the input current rating of the power conversion unit. The input current at 480 volts for a 10-hp motor is 22.2 amperes.

Per 430.122(A), 22.2 A × 1.25 = 27.75 amperes. The minimum size copper conductor based on 75°C termination rating is 10 AWG (35 amperes per Table 310.16).

Step 2: Output Conductors. The output conductors from the drive to the motor are based on the Table 430.250 full load current value for a 10 hp, 3-phase, 480-volt motor, which is 14 amperes.