

## Minimum Supply Wire Size Recommendations for Compressor Packages Utilizing Variable Frequency Drives

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Safety is the driving force in the determination of minimum recommended supply wire sizes for variable speed compressor packages. With this in mind, all wire size recommendations should be based on meeting, or exceeding, the minimum requirements of the National Electrical Code (NEC).

In determining the proper minimum wire size recommendation, NEC 430.122 lists the preliminary requirement to obtain the drive rated input ampacity which is listed on the drive data label, and in the appropriate drive manual. All drive input amps are added together, as applicable. Add the ancillary load amps from coils, controller, power supply and other ancillary loads to the drive input amps. Then multiply this sum by 1.25 to obtain package ampacity which can be used for wire sizing, at 30°C ambient, per NEC Table 310.16. Please note that the 1.25 multiplier to the drive input ampacity is required per NEC 430.122. Adding the ancillary load ampacity total to the drive input ampacity, prior to performing the 1.25 multiplier calculation, serves to add a small amount of increased safety factor for wire sizing. An example of this procedure is demonstrated as follows:

- For a 460V, 40 kW compressor, the drive input amps are listed as 90A.
- The remaining ancillary loads total 10A.
- $90A + 10A = 100A \times 1.25 = 125A$  at 30°C ambient (Package Amps)

Based on the example above, if a wire run length of 100 feet of 75°C copper wire is used and all terminal connection points are rated for a minimum of 75°C, then copper wire size number 1 AWG can be used for this application as it is rated for 130A at 30°C ambient which meets the minimum package conductor ampacity requirement of 125A. Keep in mind that the length of the wire run to the compressor is important as it directly affects voltage drop.

Most drive applications utilize 40 °C or 45°C for ambient temperature conditions. These conditions require conductor ampacity correction(s) to allow for the higher temperatures. The NEC requires that conductor sizes for use in other than 30°C ambient temperature be determined by using the appropriate multiplier listed at the bottom section of NEC Table 310.16, and selecting the conductor size that has sufficient ampacity, after correction(s), to meet the load requirements. Conductor ampacity is to be corrected, not "Package Amps". An example of this procedure, utilizing the example shown above, is as follows:

- The 1 AWG copper conductors referenced, above, are rated for 130 amperes based on an ambient temperature of 30°C and a conductor temperature rating of 75°C.
- For 40°C ambient conditions, the 75°C conductor ampacity correction factor is 0.88 resulting in the 1 AWG copper conductor ampacity being corrected from 130 amperes at 30°C to 114.4 (130 x .88) amperes at 40°C ambient. Number 1 AWG wire is not sufficient for this application at 40°C because the corrected conductor ampacity is less than the required minimum of 125 amperes.

- For 45°C ambient conditions, the 75°C conductor ampacity correction factor is 0.82 resulting in the 1 AWG copper conductor ampacity being corrected from 130 amperes at 30°C to 106.6 (130 x .82) amperes at 45°C ambient. Number 1 AWG wire is not sufficient for this application at 45°C because the corrected conductor ampacity is less than the required minimum of 125 amperes.

As stated above, the corrected number 1 AWG conductor ampacity is insufficient for use with this application in 40 or 45°C ambient conditions. Utilizing the appropriate correction factors, the 40°C application would require a minimum copper conductor size of 1/0, and the 45°C application would require a minimum copper conductor size of 2/0 to meet minimum NEC requirements.

Last but not least, NEC 310.15 (B) (2) (a), and the associated Table, reference additional conductor ampacity correction multipliers that must be applied if more than three current carrying conductors are to be installed in a single conduit (raceway). An example of this procedure is demonstrated as follows:

- Assume that a 460V, 135 kW compressor has package amperage of 265A for wire sizing.
- The minimum recommended 75°C copper supply wire size for six conductors (two parallel sets) in a single conduit is 3/0 AWG for 40°C ambient conditions. Based on the proper copper conductor ampacity corrections for ambient temperature and six conductors (two parallel sets) in a single conduit, the corrected combined ampacity of both sets of the 3/0 AWG copper conductors is 281.6A which meets or exceeds the wire sizing requirements ( $200A \times 2 = 400A \times 0.88 = 352A \times 0.8 = 281.6$  corrected conductor ampacity).
- The minimum recommended 75°C copper wire size for six conductors (two parallel sets) is 4/0 AWG for 45°C ambient conditions. Based on the proper copper conductor ampacity corrections for ambient temperature and six conductors (two parallel sets) in a single conduit, the corrected combined ampacity of both sets of the 4/0 AWG copper conductors is 301.76A which meets or exceeds the wire sizing requirements ( $230A \times 2 = 460A \times 0.82 = 377.2A \times 0.8 = 301.76$  corrected conductor ampacity).

Again, the minimum recommended supply wire sizes should be determined based on personnel and equipment safety being of the utmost concern. The final decision on the proper supply wire size should be reached by a qualified electrical professional, after taking into account all installation site specific variables such as the type of wire used, temperature rating of lowest rated terminal connection point, length of the required wire run, actual supply voltage, maximum permitted voltage drop, ambient temperature, etcetera. As you can plainly see, there are many variables to be taken into account to ensure a minimum level of personnel and equipment safety. Everyone benefits when safety is the priority!

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