Motors

JADELearning
Power Your Career

# AC & DC Motors
# (2017 NEC)

## Instructors: Mike Caudle, Gary Mullis, Ben Wesley

**Class Schedule:**

| | |
|---|---|
| 12:45 PM – 1:45 PM | Part 1 |
| 1:45 PM – 1:55 PM | Break |
| 1:55 PM – 3:15 PM | Part 2 |
| 3:15 PM – 3:25 PM | Break |
| 3:25 PM – 4:30 PM | Part 3 |

**Full class handouts:** www.jadelearning.com/ncclass

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1

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# CE Class Information

- **This class is worth 4 hours of continuing education credit for the North Carolina Board of Examiners of Electrical Contractors.**
- **Within 2 business days:**
  - ❖ **You will receive your certificate of completion by email.**
  - ❖ **You will receive an emailed discount code for $25 off any online or homestudy course.**
  - ❖ **Your hours will be reported to North Carolina.**

**If you need to reciprocate your hours to another state or have any questions, please call the office at 1-800-443-5233 or email registrar@jadelearning.com**

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2

## Course Objectives

At the completion of this 4-hour course you will be able to:

- Identify and Locate NEC Motor Requirements
- Collect Necessary Data to Perform Motor Calculations
- Understand safety requirements for motors
- Understand the different methods of motor control







## Article 430 Motors, Motor Control Circuits, and Controllers

430.1 Scope

This article covers:

- ✓ Motors
- ✓ Motor branch-circuit and feeder conductors and their protection
- ✓ Motor overload protection
- ✓ Motor control circuits
- ✓ Motor controllers, and
- ✓ Motor control centers

Motors

# Motors AC & DC

- **Understanding motor construction, operation, and installation requirements and using the proper test instruments is critical in troubleshooting motor circuits.**
- **Understanding the basic theory behind motors, nameplate data, and how the control circuits effect motor operation is invaluable for those maintaining motor reliability and installing motors.**



5

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# Motor Rotation Basics

- **An electromechanical device used to convert electrical energy into rotating mechanical energy**
- **DC types**
  - **Series or Shunt wound**
  - **Compound (contains both series and shunt windings)**
  - **Permanent Magnet**
- **AC types**
  - **Single-phase**
  - **Three-phase**



6

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# Motor Rotation Basics

- **Like magnetic forces repel**
- **Unlike magnetic forces attract**
- **All motors establish two magnetic fields**
  - **One in the stationary part**
  - **One in the rotating part**
- **The two magnetic fields interact to cause rotation**
- **How the current and the type of current (AC or DC) is applied determines the type of motor**

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7

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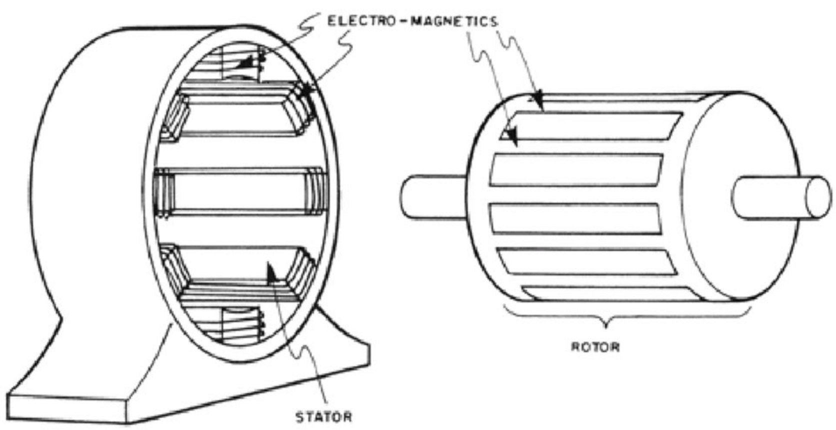
# Motor Rotation Basics

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8

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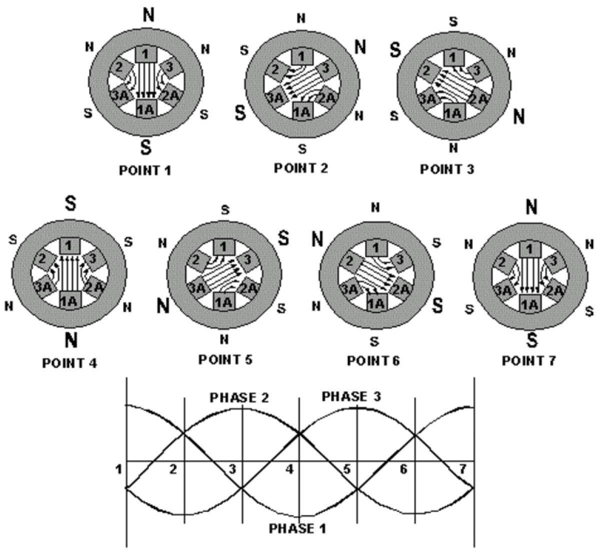
# Motor Rotation Basics




As each phase builds and returns to zero, a magnetic field builds and collapses in the same winding – The magnetic field rotates

This produces a magnetic field in the rotor. Two fields interact and rotation results

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9

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Click Here for Video

**Special Thanks**
**Sajith K V**

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10

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# Motor Rotation Basics

- $N_S$ = Synchronous Speed (speed of the rotating magnetic field)
  - Two-pole motor: 3600 RPM
  - Four-pole: 1800 RPM
- $N_R$ = Rotor Speed
- Slip is the difference between the two and measured as a percentage:

$$\% \text{ Slip} = \frac{N_S - N_R}{N_S} \text{ X's } 100$$

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11

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# Motor Rotation Basics

| Poles | RPM @ 60Hz |
|---|---|
| 2 | 3600 |
| 4 | 1800 |
| 6 | 1200 |
| 8 | 900 |
| 10 | 720 |
| 12 | 600 |

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12

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# Sizing Motor Circuits

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13

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## How to Remember FLC vs FLA

***FLC****= Full-Load Current =* ***F****ull* ***L****oad* ***C****odebook*. This is the value the Codebook provides for sizing motor circuit components. "C" is for Codebook

***FLA****= Full-Load Amps =* ***F****ull* ***L****oad* ***A****ctual*. This is the actual motor current value and it is provided on the nameplate of the motor. "A" is for Actual.

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14

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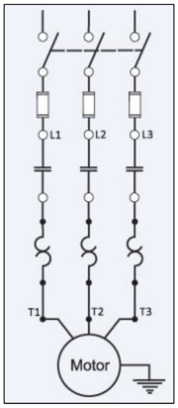
**FLA vs. FLC -** To size the conductors for this motor, do we use FLC or FLA?




***ACME MOTOR*** made in USA

| | | | | | |
|---|---|---|---|---|---|
| HP | 20 | Hz | 60 | SF | 1.0 |
| Volts | 460 | Ph | 3 | Frame | 286U |
| FLA | 24.5 | Design | B | Enc | TEFC |
| RPM | 1760 | Code Ltr | G | Ins Class | F |
| Duty | Cont | Amb | 65°C | FL Eff | 90.2 |
| Catalog Number: AEM2334-4 | | | | PF | 86 |

FLA is found here.





Motors

## What is the difference between FLA and FLC?

FLA is found on the nameplate of the motor, FLC is found in the NEC tables

A 25 Hp, 3 phase induction motor will have an ampacity of __________ when the voltage is 460 and the Power Factor is .8

34 x 1.25 =

| Power Factor | Multiply By |
|---|---|
| 90% | 1.1 |
| 80% | 1.25 |

**Table 430.250 Full-Load Current, Three-Phase Alternating-Current Motors The following va speeds usual for belted motors and motors with normal torque characteristics. The voltages permitted for system voltage ranges of 110 to 120, 220 to 240, 4**

| Horsepower | Induction-Type Squirrel Cage and Wound Rotor (Amperes) | | | | | |
|---|---|---|---|---|---|---|
| | 115V | 200V | 208V | 230V | 460V | 575V |
| 1⁄2 | 4.4 | 2.5 | 2.4 | 2.2 | 1.1 | 0.9 |
| 3⁄4 | 6.4 | 3.7 | 3.5 | 3.2 | 1.6 | 1.3 |
| 1 | 8.4 | 4.8 | 4.6 | 4.2 | 2.1 | 1.7 |
| 11⁄2 | 12.0 | 6.9 | 6.6 | 6.0 | 3.0 | 2.4 |
| 2 | 13.6 | 7.8 | 7.5 | 6.8 | 3.4 | 2.7 |
| 3 | — | 11.0 | 10.6 | 9.6 | 4.8 | 3.9 |
| 5 | — | 17.5 | 16.7 | 15.2 | 7.6 | 6.1 |
| 71⁄2 | — | 25.3 | 24.2 | 22 | 11 | 9 |
| 10 | — | 32.2 | 30.8 | 28 | 14 | 11 |
| 15 | — | 48.3 | 46.2 | 42 | 21 | 17 |
| 20 | — | 62.1 | 59.4 | 54 | 27 | 22 |
| 25 | — | 78.2 | 74.8 | 68 | 34 | 27 |
| 30 | — | 92 | 88 | 80 | 40 | 32 |
| 40 | — | 120 | 114 | 104 | 52 | 41 |
| 50 | — | 150 | 143 | 130 | 65 | 52 |
| 60 | — | 177 | 169 | 154 | 77 | 62 |

Motors

## What is the difference between FLA and FLC?

**Table 430.250 Full-Load Current, Three-Phase Alternating-Current Motors The following values of full-load currents are typical for motors running at speeds usual for belted motors and motors with normal torque characteristics. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.**

| Horsepower | Induction-Type Squirrel Cage and Wound Rotor (Amperes) | | | | | | | Synchronous-Type Unity Power Factor* (Amperes) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 115V | 200V | 208V | 230V | 460V | 575V | 2300V | 230V | 460 V | 575 V | 2300 V |
| 1/2 | 4.4 | 2.5 | 2.4 | 2.2 | 1.1 | 0.9 | — | — | — | — | — |
| 3/4 | 6.4 | 3.7 | 3.5 | 3.2 | 1.6 | 1.3 | — | — | — | — | — |
| 1 | 8.4 | 4.8 | 4.6 | 4.2 | 2.1 | 1.7 | — | — | — | — | — |
| 1 1/2 | 12.0 | 6.9 | 6.6 | 6.0 | 3.0 | 2.4 | — | — | — | — | — |
| 2 | 13.6 | 7.8 | 7.5 | 6.8 | 3.4 | 2.7 | — | — | — | — | — |
| 3 | — | 11.0 | 10.6 | 9.6 | 4.8 | 3.9 | — | — | — | — | — |
| 5 | — | 17.5 | 16.7 | 15.2 | 7.6 | 6.1 | — | — | — | — | — |
| 7 1/2 | — | 25.3 | 24.2 | 22 | 11 | 9 | — | — | — | — | — |
| 10 | — | 32.2 | 30.8 | 28 | 14 | 11 | — | — | — | — | — |
| 15 | — | 48.3 | 46.2 | 42 | 21 | 17 | — | — | — | — | — |
| 20 | — | 62.1 | 59.4 | 54 | 27 | 22 | — | — | — | — | — |
| 25 | — | 78.2 | 74.8 | 68 | 34 | 27 | — | 53 | 26 | 21 | — |
| 30 | — | 92 | 88 | 80 | 40 | 32 | — | 63 | 32 | 26 | — |
| 40 | — | 120 | 114 | 104 | 52 | 41 | — | 83 | 41 | 33 | — |
| 50 | — | 150 | 143 | 130 | 65 | 52 | — | 104 | 52 | 42 | — |
| 60 | — | 177 | 169 | 154 | 77 | 62 | 16 | 123 | 61 | 49 | 12 |

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17

Motors

## Sizing the Motor Conductors

**430.6 (A) (1)**

**(1) Table Values.** Other than for motors built for low speeds (less than 1200 RPM) or high torques, and for multispeed motors*, the values given in Table 430.247, Table 430.248, Table 430.249, and Table 430.250* shall be used to determine the ampacity of conductors or ampere ratings of switches, branch-circuit short-circuit and ground-fault protection, instead of the actual current rating marked on the motor nameplate.

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18

Motors

# Table 430.247

**Table 430.247 Full-Load Current in Amperes, Direct-Current Motors**
The following values of full-load currents* are for motors running at base speed.

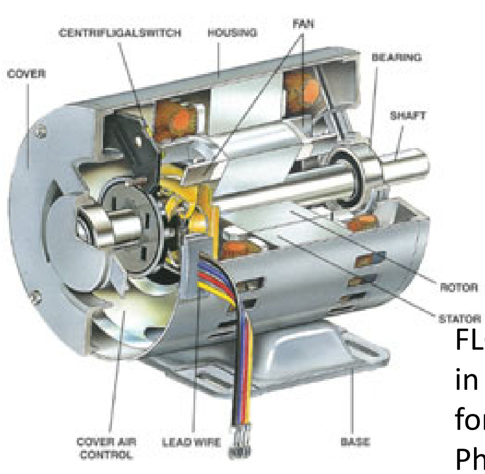
FLC is found in this Table for DC Motors

| Horsepower | Armature Voltage Rating* 90 Volts | 120 Volts | 180 Volts | 240 Volts | 500 Volts | 550 Volts |
|---|---|---|---|---|---|---|
| ¼ | 4.0 | 3.1 | 2.0 | 1.6 | — | — |
| ⅓ | 5.2 | 4.1 | 2.6 | 2.0 | — | — |
| ½ | 6.8 | 5.4 | 3.4 | 2.7 | — | — |
| ¾ | 9.6 | 7.6 | 4.8 | 3.8 | — | — |
| 1 | 12.2 | 9.5 | 6.1 | 4.7 | — | — |
| 1½ | — | 13.2 | 8.3 | 6.6 | — | — |
| 2 | — | 17 | 10.8 | 8.5 | — | — |
| 3 | — | 25 | 16 | 12.2 | — | — |
| 5 | — | 40 | 27 | 20 | — | — |
| 7½ | — | 58 | — | 29 | 13.6 | 12.2 |
| 10 | — | 76 | — | 38 | 18 | 16 |
| 15 | — | — | — | 55 | 27 | 24 |
| 20 | — | — | — | 72 | 34 | 31 |
| 25 | — | — | — | 89 | 43 | 38 |
| 30 | — | — | — | 106 | 51 | 46 |
| 40 | — | — | — | 140 | 67 | 61 |



Motors

# Table 430.248




FLC is found in this Table for Single Phase Motors

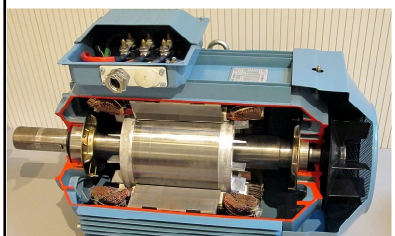
**Table 430.248 Full-Load Currents in Amperes, Single-Phase Alternating-Current Motors**
The following values of full-load currents are for motors running at usual speeds and motors with normal torque characteristics. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120 and 220 to 240 volts.

| Horsepower | 115 Volts | 200 Volts | 208 Volts | 230 Volts |
|---|---|---|---|---|
| ⅙ | 4.4 | 2.5 | 2.4 | 2.2 |
| ¼ | 5.8 | 3.3 | 3.2 | 2.9 |
| ⅓ | 7.2 | 4.1 | 4.0 | 3.6 |
| ½ | 9.8 | 5.6 | 5.4 | 4.9 |
| ¾ | 13.8 | 7.9 | 7.6 | 6.9 |
| 1 | 16 | 9.2 | 8.8 | 8.0 |
| 1½ | 20 | 11.5 | 11.0 | 10 |
| 2 | 24 | 13.8 | 13.2 | 12 |
| 3 | 34 | 19.6 | 18.7 | 17 |
| 5 | 56 | 32.2 | 30.8 | 28 |
| 7½ | 80 | 46.0 | 44.0 | 40 |
| 10 | 100 | 57.5 | 55.0 | 50 |

# Table 430.249 Full-Load Current, Two-Phase AC Motors (4-Wire)

value given. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

| | Induction-Type Squirrel Cage and Wound Rotor (Amperes) | | | | |
|---|---|---|---|---|---|
| Horsepower | 115 Volts | 230 Volts | 460 Volts | 575 Volts | 2300 Volts |
| ½ | 4.0 | 2.0 | 1.0 | 0.8 | — |
| ¾ | 4.8 | 2.4 | 1.2 | 1.0 | — |
| 1 | 6.4 | 3.2 | 1.6 | 1.3 | — |
| 1½ | 9.0 | 4.5 | 2.3 | 1.8 | — |
| 2 | 11.8 | 5.9 | 3.0 | 2.4 | — |
| 3 | — | 8.3 | 4.2 | 3.3 | — |
| 5 | — | 13.2 | 6.6 | 5.3 | — |
| 7½ | — | 19 | 9.0 | 8.0 | — |
| 10 | — | 24 | 12 | 10 | — |
| 15 | — | 36 | 18 | 14 | — |
| 20 | — | 47 | 23 | 19 | — |
| 25 | — | 59 | 29 | 24 | — |



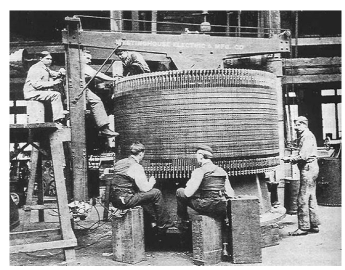
FLC is found in this Table for Two Phase Motors







# Two Phase AC Motors



- Has two voltages 90 degrees apart.
- Alternator is composed of two windings placed at 90 degrees from each other.

They require 2 energized and one grounded wire that work in two phases.
- One increases the current up to what is associated for 240v for the motion
- Other one maintains the fluidity of the current for the use of the motor.

The generators at Niagara Falls installed in 1895 were the largest generators in the world at that time and were two-phase machines.

Three-phase systems eventually replaced the original two-phase power systems for power transmission and utilization. There remain few two-phase distribution systems, with examples in Philadelphia, Pennsylvania; many buildings in Center City; and Hartford, Connecticut.

Motors

# Table 430.250 Full-Load Current, Three-Phase AC Motors

Our motor is a 20 HP motor with a FLA of 24.5A

This Table tells us the FLC is 27 A

| | Induction-Type Squirrel Cage and Wound Rotor (Amperes) | | | | | | | Synchronous-Type Unity Power Factor* (Amperes) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Horsepower | 115 Volts | 200 Volts | 208 Volts | 230 Volts | 460 Volts | 575 Volts | 2300 Volts | 230 Volts | 460 Volts | 575 Volts | 2300 Volts |
| ½ | 4.4 | 2.5 | 2.4 | 2.2 | 1.1 | 0.9 | — | — | — | — | — |
| ¾ | 6.4 | 3.7 | 3.5 | 3.2 | 1.6 | 1.3 | — | — | — | — | — |
| 1 | 8.4 | 4.8 | 4.6 | 4.2 | 2.1 | 1.7 | — | — | — | — | — |
| 1½ | 12.0 | 6.9 | 6.6 | 6.0 | 3.0 | 2.4 | — | — | — | — | — |
| 2 | 13.6 | 7.8 | 7.5 | 6.8 | 3.4 | 2.7 | — | — | — | — | — |
| 3 | — | 11.0 | 10.6 | 9.6 | 4.8 | 3.9 | — | — | — | — | — |
| 5 | — | 17.5 | 16.7 | 15.2 | 7.6 | 6.1 | — | — | — | — | — |
| 7½ | — | 25.3 | 24.2 | 22 | 11 | 9 | — | — | — | — | — |
| 10 | — | 32.2 | 30.8 | 28 | 14 | 11 | — | — | — | — | — |
| 15 | — | 48.3 | 46.2 | 42 | 21 | 17 | — | — | — | — | — |
| 20 | — | 62.1 | 59.4 | 54 | 27 | 22 | — | — | — | — | — |
| 25 | — | 78.2 | 74.8 | 68 | 34 | 27 | — | 53 | 26 | 21 | — |
| 30 | — | 92 | 88 | 80 | 40 | 32 | — | 63 | 32 | 26 | — |
| 40 | — | 120 | 114 | 104 | 52 | 41 | — | 83 | 41 | 33 | — |

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23

Motors

# FLA vs. FLC

The motor full-load current (FLC) ratings listed in Tables 430.247, 430.248, and 430.250 are used to determine:

1. Conductor ampacity [430.22].
2. Branch circuit short circuit and ground fault overcurrent device size [430.52 and 430.62].
3. Ampere rating of disconnecting switches [430.110].

The nameplate full-load ampere (FLA) rating is the current the motor draws while producing its rated horsepower load at its rated voltage, based on its rated efficiency and power factor. The current the motor actually draws depends on the actual voltage at the motor terminals and the load the motor is trying to drive. The current increases if the load increases or if the voltage decreases.

1. The FLA will be used to size our overloads.

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24

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# FLA vs. FLC

**Our motor is a 20 HP 3 phase AC motor. The FLA is 24.5 found on the nameplate. The FLC is found in Table 430.250.**

Using Table 430.250
A 20HP, 3 phase, 460-volt motor will draw _______ amps full load current.

How many amps did the nameplate say? ________

Section 430.22 tells us we now have to ______________________________ .



Motors

# Table 430.250 Full-Load Current, Three-Phase AC Motors

Our motor is a 20 HP motor with a FLA of 24.5A
This Table tells us the FLC is 27 A

| | Induction-Type Squirrel Cage and Wound Rotor (Amperes) | | | | | | | Synchronous-Type Unity Power Factor* (Amperes) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Horsepower | 115 Volts | 200 Volts | 208 Volts | 230 Volts | 460 Volts | 575 Volts | 2300 Volts | 230 Volts | 460 Volts | 575 Volts | 2300 Volts |
| ½ | 4.4 | 2.5 | 2.4 | 2.2 | 1.1 | 0.9 | — | — | — | — | — |
| ¾ | 6.4 | 3.7 | 3.5 | 3.2 | 1.6 | 1.3 | — | — | — | — | — |
| 1 | 8.4 | 4.8 | 4.6 | 4.2 | 2.1 | 1.7 | — | — | — | — | — |
| 1½ | 12.0 | 6.9 | 6.6 | 6.0 | 3.0 | 2.4 | — | — | — | — | — |
| 2 | 13.6 | 7.8 | 7.5 | 6.8 | 3.4 | 2.7 | — | — | — | — | — |
| 3 | — | 11.0 | 10.6 | 9.6 | 4.8 | 3.9 | — | — | — | — | — |
| 5 | — | 17.5 | 16.7 | 15.2 | 7.6 | 6.1 | — | — | — | — | — |
| 7½ | — | 25.3 | 24.2 | 22 | 11 | 9 | — | — | — | — | — |
| 10 | — | 32.2 | 30.8 | 28 | 14 | 11 | — | — | — | — | — |
| 15 | — | 48.3 | 46.2 | 42 | 21 | 17 | — | — | — | — | — |
| 20 | — | 62.1 | 59.4 | 54 | 27 | 22 | — | — | — | — | — |
| 25 | — | 78.2 | 74.8 | 68 | 34 | 27 | — | 53 | 26 | 21 | — |
| 30 | — | 92 | 88 | 80 | 40 | 32 | — | 63 | 32 | 26 | — |
| 40 | — | 120 | 114 | 104 | 52 | 41 | — | 83 | 41 | 33 | — |

Motors

## FLA vs. FLC

**Our motor is a 20 HP 3 phase AC motor. The FLA is 24.5 found on the nameplate. The FLC is found in Table 430.250.**

Using Table 430.250
A 20HP, 3 phase, 460-volt motor will draw _______ amps full load current.

How many amps did the nameplate say? ________

Section 430.22 tells us we now have to ______________________________ .

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27

Motors

## FLA vs. FLC

**Our motor is a 20 HP 3 phase AC motor. The FLA is 24.5 found on the nameplate. The FLC is found in Table 430.250.**

Using Table 430.250
A 20HP, 3 phase, 460-volt motor will draw _______ amps full load current.

How many amps did the nameplate say? ________

Section 430.22 tells us we now have to ______________________________ .

We must now go to Table 310.15(B)16 and find a conductor with insulation of THWN that can carry our motor load, the *terminals are rated at 60 degrees Celsius*, the size is _______.

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28

Motors

# Conductor Size - Table 310.15(B)16

| Size AWG or kcmil | Temperature Rating of Conductor [See Table 310.104(A).] | | | | | | Size AWG or kcmil |
|---|---|---|---|---|---|---|---|
| | 60°C (140°F) | 75°C (167°F) | 90°C (194°F) | 60°C (140°F) | 75°C (167°F) | 90°C (194°F) | |
| | Types TW, UF | Types RHW, THHW, THW, THWN, XHHW, USE, ZW | Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2 | Types TW, UF | Types RHW, THHW, THW, THWN, XHHW, USE | Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2 | |
| | COPPER | | | ALUMINUM OR COPPER-CLAD ALUMINUM | | | |
| 18** | — | — | 14 | — | — | — | — |
| 16** | — | — | 18 | — | — | — | — |
| 14** | 15 | 20 | 25 | — | — | — | — |
| 12** | 20 | 25 | 30 | 15 | 20 | 25 | 12** |
| 10** | 30 | 35 | 40 | 25 | 30 | 35 | 10** |
| 8 | 40 | 50 | 55 | 35 | 40 | 45 | 8 |
| 6 | 55 | 65 | 75 | 40 | 50 | 55 | 6 |

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29

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# FLA vs. FLC

**Our motor is a 20 HP 3 phase AC motor. The FLA is 24.5 found on the nameplate. The FLC is found in Table 430.250.**

Using Table 430.250
A 20HP, 3 phase, 460-volt motor will draw _______ amps full load current.

How many amps did the nameplate say? ________

Section 430.22 tells us we now have to ______________________________ .

We must now go to Table 310.15(B)16 and find a conductor with insulation of THWN that can carry our motor load, the *terminals are rated at 60 degrees Celsius*, the size is _______.

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30

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# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| 1 FRAME | 2 TYPE (ENCL.) | 3 INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| 4 HP | 5 RPM | 6 VOLTS | 7 FLA | 8 HZ. | 9 SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| 10 CODE LTR | 11 PHASE | 12 DUTY | 13 AMB. | 14 BEARINGS | |
| H | 3 | CONT. | 40ºC | DE | ODE |
| | | | | 6312 | 6311 |

## 1. Frame

Motor frame sizes have been standardized with a uniform frame size numbering system. The system was developed by NEMA and specific frame sizes have been assigned to standard motor ratings based on enclosure, horsepower, and speed.

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31

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| 1 FRAME | 2 TYPE (ENCL.) | 3 INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| 4 HP | 5 RPM | 6 VOLTS | 7 FLA | 8 HZ. | 9 SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| 10 CODE LTR | 11 PHASE | 12 DUTY | 13 AMB. | 14 BEARINGS | |
| H | 3 | CONT. | 40ºC | DE | ODE |
| | | | | 6312 | 6311 |

**The 7 most common types of enclosures are:**

1. Open Drip Proof (ODP) ...
2. Totally Enclosed Fan Cooled (TEFC) ...
3. Totally Enclosed Non-Ventilated (TENV) ...
4. Totally Enclosed Air Over (TEAO) ...
5. Totally Enclosed Wash down (TEWD) ...
6. Explosion-proof **enclosures** (EXPL) ...
7. Hazardous Location (HAZ)

## 2. Type/Enclosure

This designation, often shown as "ENCL". On the nameplate, classifies the motor as its degree of protection from its environment, and its method of cooling.

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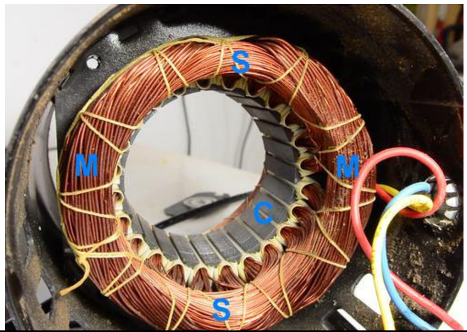
32

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| 1 FRAME | 2 TYPE (ENCL.) | 3 INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| 4 HP | 5 RPM | 6 VOLTS | 7 FLA | 8 HZ. | 9 SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| 10 CODE LTR | 11 PHASE | 12 DUTY | 13 AMB. | 14 BEARINGS | |
| | | | | DE | ODE |
| H | 3 | CONT. | 40°C | 6312 | 6311 |




**3. INSUL. Class / Insulation Class**

An industry standard classification of the thermal tolerance of the motor winding. Insulation is crucial in a motor. This determined by the ambient temperature, the heat generated at fully loaded conditions (temperature rise), and the thermal capacity of the motor insulation. These materials are classified as A, B, F, and H.





Motors

# Nameplate Information

| Insulation Class | 1.15 SF | 1.0 SF |
|---|---|---|
| A | 115°C | 105°C |
| B | 140°C | 130°C |
| F | 165°C | 155°C |
| H | --- | 180°C |

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| ❶ FRAME | ❷ TYPE (ENCL.) | ❸ INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| ❹ HP | ❺ RPM | ❻ VOLTS | ❼ FLA | ❽ HZ. | ❾ SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| ❿ CODE LTR | ⓫ PHASE | ⓬ DUTY | ⓭ AMB. | ⓮ BEARINGS | |
| H | 3 | CONT. | 40ºC | DE | ODE |
| | | | | 6312 | 6311 |

## 4. Horsepower

Shaft horsepower is a measure of the motors mechanical output rating, its ability to deliver the torque required for the load at rated speed. It is usually given in "HP" on the nameplate. The standardized NEMA table of motor horsepower ratings run from 1 to 450 HP. When application horsepower requirements fall between two standardized values, the larger size is usually chosen. In some instances, motors may be rated in KW. (746 watts per motor horsepower)

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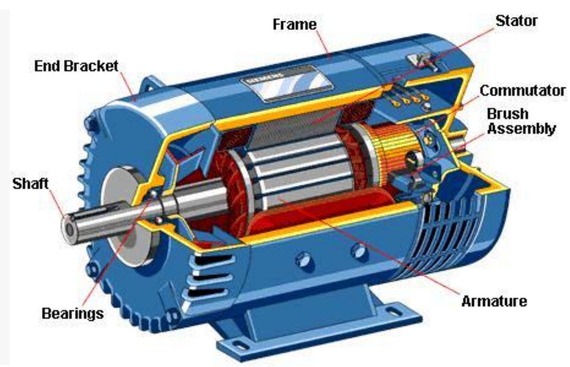
35

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| ❶ FRAME | ❷ TYPE (ENCL.) | ❸ INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| ❹ HP | ❺ RPM | ❻ VOLTS | ❼ FLA | ❽ HZ. | ❾ SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| ❿ CODE LTR | ⓫ PHASE | ⓬ DUTY | ⓭ AMB. | ⓮ BEARINGS | |
| H | 3 | CONT. | 40ºC | DE | ODE |
| | | | | 6312 | 6311 |




## 5. RPM – Revolutions Per Minute

Full load RPM (Revolutions Per Minute) of the motor is the approximate speed under full-load conditions, when the voltage and frequency are at the rated values. An induction motor's speed is always less than synchronous speed and drops off as load increases.

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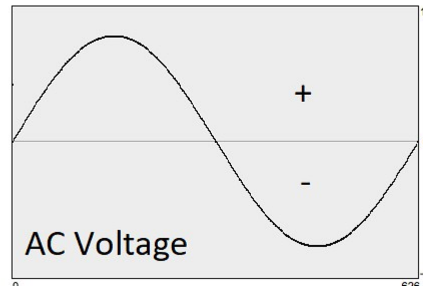
36

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| 1 FRAME | 2 TYPE (ENCL.) | 3 INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| 4 HP | 5 RPM | 6 VOLTS | 7 FLA | 8 HZ. | 9 SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| 10 CODE LTR | 11 PHASE | 12 DUTY | 13 AMB. | 14 BEARINGS | |
| | | | | DE | ODE |
| H | 3 | CONT. | 40ºC | 6312 | 6311 |




**6. Voltage**

The rated voltage is the voltage at which the motor is designed to operate and yield optimal performance. Nameplate defined parameters for the motor such as power factor, efficiency, torque, and current are at rated voltage and frequency.

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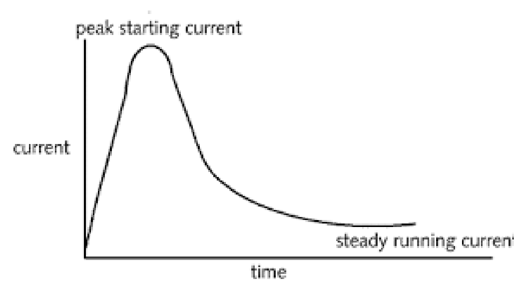
37

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| 1 FRAME | 2 TYPE (ENCL.) | 3 INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| 4 HP | 5 RPM | 6 VOLTS | 7 FLA | 8 HZ. | 9 SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| 10 CODE LTR | 11 PHASE | 12 DUTY | 13 AMB. | 14 BEARINGS | |
| | | | | DE | ODE |
| H | 3 | CONT. | 40ºC | 6312 | 6311 |




**7. FLA – Full Load Amperage**

When the full-load torque and horsepower is reached, the corresponding amperage is known as the full load amperage (FLA). The nameplate FLA is used to select the correct wire size, motor starter, and overload protection devices necessary to serve and protect the motor.

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38

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| ❶ FRAME | ❷ TYPE (ENCL.) | ❸ INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| ❹ HP | ❺ RPM | ❻ VOLTS | ❼ FLA | ❽ HZ. | ❾ SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| ❿ CODE LTR | ⓫ PHASE | ⓬ DUTY | ⓭ AMB. | ⓮ BEARINGS | |
| | | | | DE | ODE |
| H | 3 | CONT. | 40ºC | 6312 | 6311 |

The choice of 60 Hz for the AC line frequency is a win for Nikola Tesla's engineering, but 110 V is an example of compromise for Edison's business interests.

**8. HZ - Hertz**

Rated frequency is the frequency the motor is designed to operate at and is represented in Hertz (Hz, cycles per second). In North America and Canada, this frequency is 60 Hz (cycles). In other parts of the world, the frequency may be 50 or 60 Hz.

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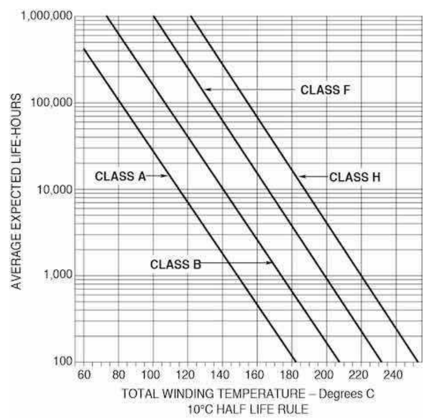
39

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| ❶ FRAME | ❷ TYPE (ENCL.) | ❸ INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| ❹ HP | ❺ RPM | ❻ VOLTS | ❼ FLA | ❽ HZ. | ❾ SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| ❿ CODE LTR | ⓫ PHASE | ⓬ DUTY | ⓭ AMB. | ⓮ BEARINGS | |
| | | | | DE | ODE |
| H | 3 | CONT. | 40ºC | 6312 | 6311 |




**9. SF – Service Factor**

Motor Service Factor (SF) is the percentage of overloading the motor can handle for short periods when normally within the correct voltage tolerances.

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40

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| ❶ FRAME | ❷ TYPE (ENCL.) | ❸ INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| ❹ HP | ❺ RPM | ❻ VOLTS | ❼ FLA | ❽ HZ. | ❾ SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| ❿ CODE LTR | ⓫ PHASE | ⓬ DUTY | ⓭ AMB. | ⓮ BEARINGS | |
| | | | | DE | ODE |
| H | 3 | CONT. | 40°C | 6312 | 6311 |

| NEMA Code Letter | kVA/HP with locked rotor | Approximate Mid-Range Value |
|---|---|---|
| A | 0 - 3.14 | 1.6 |
| B | 3.15 - 3.55 | 3.3 |
| C | 3.55 - 3.99 | 3.8 |
| D | 4.0 - 4.49 | 4.3 |
| E | 4.5 - 4.99 | 4.7 |
| F | 5.0 - 5.59 | 5.3 |
| G | 5.6 - 6.29 | 5.9 |
| H | 6.3 - 7.09 | 6.7 |
| J | 7.1 - 7.99 | 7.5 |
| K | 8.0 - 8.99 | 8.5 |
| L | 9.0 - 9.99 | 9.5 |
| M | 10.0 - 11.19 | 10.6 |
| N | 11.2 - 12.49 | 11.8 |
| P | 12.5 - 13.99 | 13.2 |
| R | 14.0 - 15.99 | 15.0 |
| S | 16.0 - 17.99 | |

## 10. Code Letter – Locked Rotor

When AC motors are started with full voltage applied, they create an inrush current that is usually many times greater than the value of the Full-Load Current. The value of this high current can be important on some installations because it can cause a voltage dip that might affect other equipment. The start inrush current has been standardized and defined by a series of code letters which group motors based on the amount of inrush in terms of kilovolt amperes.

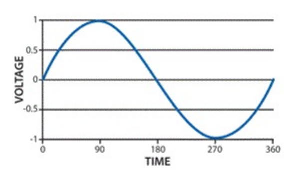
 41

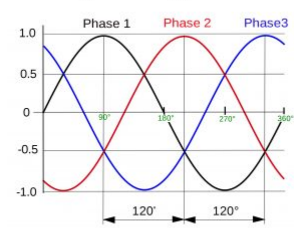
41

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| ❶ FRAME | ❷ TYPE (ENCL.) | ❸ INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| ❹ HP | ❺ RPM | ❻ VOLTS | ❼ FLA | ❽ HZ. | ❾ SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| ❿ CODE LTR | ⓫ PHASE | ⓬ DUTY | ⓭ AMB. | ⓮ BEARINGS | |
| | | | | DE | ODE |
| H | 3 | CONT. | 40°C | 6312 | 6311 |




## 11. Phase

This represents the number of AC power line supplying the motor. Typically either single-phase or three-phase.

 42

42

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| ❶ FRAME | ❷ TYPE (ENCL.) | ❸ INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| ❹ HP | ❺ RPM | ❻ VOLTS | ❼ FLA | ❽ HZ. | ❾ SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| ❿ CODE LTR | ⓫ PHASE | ⓬ DUTY | ⓭ AMB. | ⓮ BEARINGS | |
| | | | | DE | ODE |
| H | 3 | CONT. | 40ºC | 6312 | 6311 |

**12. Duty**

NEMA motors refer to duty cycle as continuous, intermittent, or special duty (typically expressed in minutes). Continuous Duty motors work at a constant load for enough time to reach temperature equilibrium. Intermittent duty motors work at a constant load, but not long enough to reach temperature equilibrium and the off period is long enough for the motor to return to ambient temperature.

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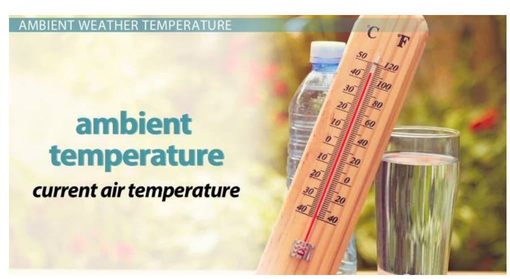
43

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| ❶ FRAME | ❷ TYPE (ENCL.) | ❸ INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| ❹ HP | ❺ RPM | ❻ VOLTS | ❼ FLA | ❽ HZ. | ❾ SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| ❿ CODE LTR | ⓫ PHASE | ⓬ DUTY | ⓭ AMB. | ⓮ BEARINGS | |
| | | | | DE | ODE |
| H | 3 | CONT. | 40ºC | 6312 | 6311 |




**13. AMB – Ambient Temperature**

The maximum ambient temperature at which the motor can operate and still be within the tolerance of the insulation class at the maximum temperature rise.

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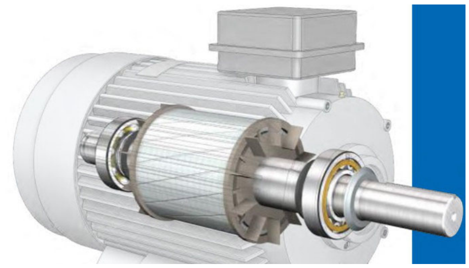
44

Motors

# Nameplate Information

| AC MOTOR | | | | MADE IN USA | |
|---|---|---|---|---|---|
| ❶ FRAME | ❷ TYPE (ENCL.) | ❸ INSUL. CLASS | IDENTIFICATION NO. | | |
| 324T | TEFC | F | 8779787246 | | |
| ❹ HP | ❺ RPM | ❻ VOLTS | ❼ FLA | ❽ HZ. | ❾ SF |
| 25 | 1760 | 230 / 460 | 60 / 30 | 60 | 1.15 |
| ❿ CODE LTR | ⓫ PHASE | ⓬ DUTY | ⓭ AMB. | ⓮ BEARINGS | |
| | | | | DE | ODE |
| H | 3 | CONT. | 40ºC | 6312 | 6311 |



## 14. Bearings

Though NEMA does not require it, many manufacturers supply nameplate data on bearings. Many special bearings are applied in motors for reasons such as high speed, high temperature, high thrust, or low noise. The types of bearings used are Sleeve, Ball, Ball and Sleeve, and Roller.

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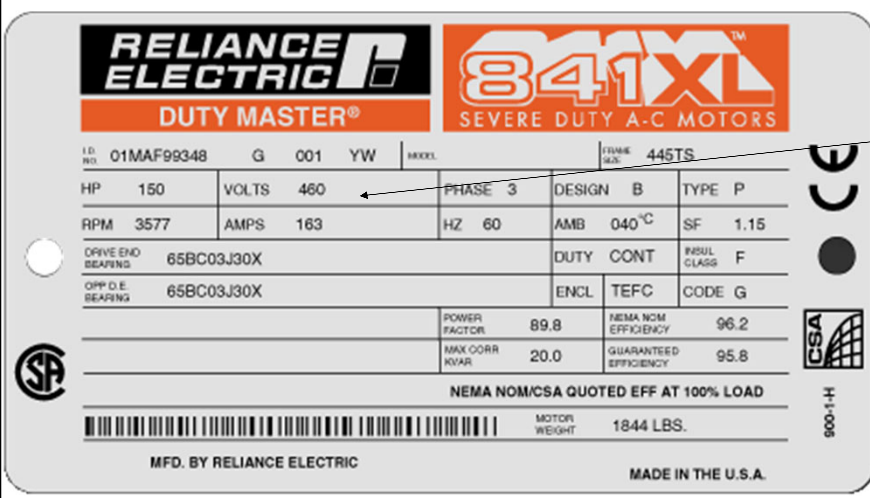
45

Motors

# Fuse Size




Let us determine the size of the fuse for this 150 HP Motor.

The FLA is 163 Amps.

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46

Motors

# Fuse Size

150 HP Motor.
FLA is 163 Amps.

**Table 430.52 Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices**

| | Percentage of Full-Load Current | | | |
|---|---|---|---|---|
| Type of Motor | Nontime Delay Fuse[1] | Dual Element (Time-Delay) Fuse[1] | Instantaneous Trip Breaker | Inverse Time Breaker[2] |
| Single-phase motors | 300 | 175 | 800 | 250 |
| AC polyphase motors other than wound-rotor | 300 | 175 | 800 | 250 |
| Squirrel cage — other than Design B energy-efficient | 300 | 175 | 800 | 250 |
| Design B energy-efficient | 300 | 175 | 1100 | 250 |
| Synchronous[3] | 300 | 175 | 800 | 250 |
| Wound-rotor | 150 | 150 | 800 | 150 |
| DC (constant voltage) | 150 | 150 | 250 | 150 |

Table 430.52 Requires us to use the FLC which is found in Table 430.250.

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47

Motors

# Fuse Size - Table 430.250

150 HP Motor.
FLA is 163 Amps.

| Horsepower | 115 Volts | 200 Volts | 208 Volts | 230 Volts | 460 Volts | 575 Volts | 2: |
|---|---|---|---|---|---|---|---|
| ½ | 4.4 | 2.5 | 2.4 | 2.2 | 1.1 | 0.9 | |
| ¾ | 6.4 | 3.7 | 3.5 | 3.2 | 1.6 | 1.3 | |
| 1 | 8.4 | 4.8 | 4.6 | 4.2 | 2.1 | 1.7 | |
| 1½ | 12.0 | 6.9 | 6.6 | 6.0 | 3.0 | 2.4 | |
| 2 | 13.6 | 7.8 | 7.5 | 6.8 | 3.4 | 2.7 | |
| 3 | — | 11.0 | 10.6 | 9.6 | 4.8 | 3.9 | |
| 5 | — | 17.5 | 16.7 | 15.2 | 7.6 | 6.1 | |
| 7½ | — | 25.3 | 24.2 | 22 | 11 | 9 | |
| 10 | — | 32.2 | 30.8 | 28 | 14 | 11 | |
| 15 | — | 48.3 | 46.2 | 42 | 21 | 17 | |
| 20 | — | 62.1 | 59.4 | 54 | 27 | 22 | |
| 25 | — | 78.2 | 74.8 | 68 | 34 | 27 | |
| 30 | — | 92 | 88 | 80 | 40 | 32 | |
| 40 | — | 120 | 114 | 104 | 52 | 41 | |
| 50 | — | 150 | 143 | 130 | 65 | 52 | |
| 60 | — | 177 | 169 | 154 | 77 | 62 | |
| 75 | — | 221 | 211 | 192 | 96 | 77 | |
| 100 | — | 285 | 273 | 248 | 124 | 99 | |
| 125 | — | 359 | 343 | 312 | 156 | 125 | |
| 150 | — | 414 | 396 | 360 | 180 | 144 | |

From Table 430.250 our FLC is 180 Amps.

From Table 430.52 our multiplier is 175%.

180 Amps x 1.75 = ________

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48

# Fuse Size

**(B) Overcurrent Devices Rated 800 Amperes or Less.** The next higher standard overcurrent device rating (above the ampacity of the conductors being protected) shall be permitted to be used, provided all of the following conditions are met:

(1) The conductors being protected are not part of a branch circuit supplying more than one receptacle for cord-and plug-connected portable loads.

(2) The ampacity of the conductors does not correspond with the standard ampere rating of a fuse or a circuit breaker without overload trip adjustments above its rating (but that shall be permitted to have other trip or rating adjustments).

(3) The next higher standard rating selected does not exceed 800 amperes.





# Fuse Size

150 HP Motor.
FLA is 163 Amps.

**Table 240.6(A) Standard Ampere Ratings for Fuses and Inverse Time Circuit Breakers**

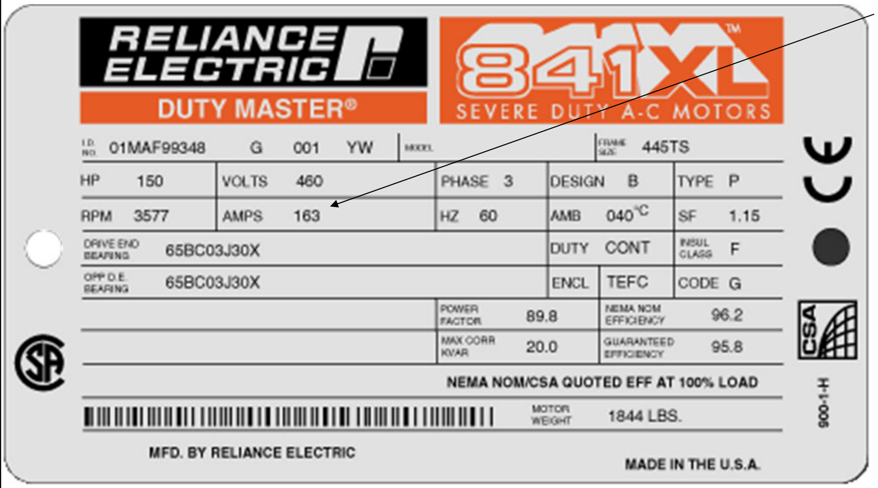
| Standard Ampere Ratings | | | | |
|---|---|---|---|---|
| 15 | 20 | 25 | 30 | 35 |
| 40 | 45 | 50 | 60 | 70 |
| 80 | 90 | 100 | 110 | 125 |
| 150 | 175 | 200 | 225 | 250 |
| 300 | 350 | 400 | 450 | 500 |
| 600 | 700 | 800 | 1000 | 1200 |
| 1600 | 2000 | 2500 | 3000 | 4000 |
| 5000 | 6000 | — | — | — |

From Table 430.52 our multiplier is 175%.

180 Amps x 1.75 = ________

Motors

## Fuse Size




A 350 Amp Fuse for a motor that has an FLA of 163 Amps?

What is the fuse protecting?

- Not the Motor!
- Not the Conductor!
- Only protecting against Ground Faults & Short Circuits!



Motors

## Setting Overloads

**Continuous duty, separate overload device as a percentage of nameplate data:**

- **Motors with a marked service factor 1.15 or greater**
  - **125%**
- **Motors with a marked temperature rise 40°C or less**
  - **125%**
- **All other motors**
  - **115%**

## Setting Overloads

**If unable to start motor, increase incrementally to a max setting of: (as a percentage of nameplate data)**

- **Motors with a marked service factor 1.15 or greater**
  - **140%**
- **Motors with a marked temperature rise 40°C or less**
  - **140%**
- **All other motors**
  - **130%**







## Setting Overloads

**Ambient temperature is the temperature of the air surrounding the motor. This is the threshold point or temperature the motor assumes when shut off and completely cool.**

**Temperature rise is the change within a motor when operating at full load. For example; if a motor in a 78°F room operates continuously at full load, the winding temperature will rise. The difference between its starting temperature and its final elevated temperature is the motor's temperature rise.**

Motors

## Calculation Exercise

Calculate branch circuit size, overcurrent protection, motor overload device size, and thermal protection for this motor

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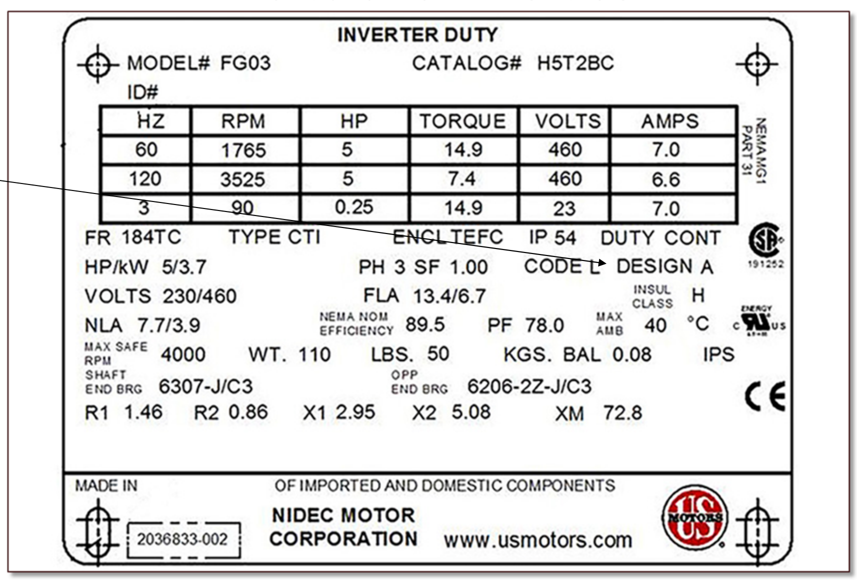
55

Motors

## Calculation Exercise

First let us discuss the motor design!




This motor will be controlled by a VFD

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56

Motors

## Calculation Exercise

**NEMA design A**
Maximum 5% slip
High to medium starting current
Normal locked rotor torque
Normal breakdown torque
Suited for a broad variety of applications - like fans and pumps

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57

Motors

## Calculation Exercise

**NEMA design B**
Maximum 5% slip
Low starting current
High locked rotor torque
Normal breakdown torque
Suited for a broad variety of applications with normal starting torques - Common in HVAC application with fans, blowers and pumps

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58

Motors

## Calculation Exercise

**NEMA design C**
Maximum 5% slip
Low starting current
High locked rotor torque
Normal breakdown torque
Suited for equipment with high inertia and high starting torques at start - Like positive displacement pumps, conveyors



Motors

## Calculation Exercise

**NEMA design D**
Maximum 5-13% slip
Low starting current
Very high locked rotor torque
Suited for equipment with very high inertia starts - like cranes, hoists etc.

Motors

**Calculate branch circuit size, overcurrent protection, motor overload device size, and thermal protection.**

- Using Table 430.250
- States that a 5HP, 3 phase 460 volt motor will draw _______ amps full load current.
- How many amps did the nameplate say? ________
- Section 430.22 tells us we now have to ______________________________ .
- We must now go to Table 310.15(b)(16)and find a conductor with insulation of THWN that can carry our motor load, the size is _______.



Motors

## Fuse Size - Table 430.250

| Horsepower | 115 Volts | 200 Volts | 208 Volts | 230 Volts | 460 Volts | 575 Volts | 2: |
|---|---|---|---|---|---|---|---|
| ½ | 4.4 | 2.5 | 2.4 | 2.2 | 1.1 | 0.9 | |
| ¾ | 6.4 | 3.7 | 3.5 | 3.2 | 1.6 | 1.3 | |
| 1 | 8.4 | 4.8 | 4.6 | 4.2 | 2.1 | 1.7 | |
| 1½ | 12.0 | 6.9 | 6.6 | 6.0 | 3.0 | 2.4 | |
| 2 | 13.6 | 7.8 | 7.5 | 6.8 | 3.4 | 2.7 | |
| 3 | — | 11.0 | 10.6 | 9.6 | 4.8 | 3.9 | |
| 5 | — | 17.5 | 16.7 | 15.2 | 7.6 | 6.1 | |
| 7½ | — | 25.3 | 24.2 | 22 | 11 | 9 | |
| 10 | — | 32.2 | 30.8 | 28 | 14 | 11 | |
| 15 | — | 48.3 | 46.2 | 42 | 21 | 17 | |
| 20 | — | 62.1 | 59.4 | 54 | 27 | 22 | |
| 25 | — | 78.2 | 74.8 | 68 | 34 | 27 | |
| 30 | — | 92 | 88 | 80 | 40 | 32 | |
| 40 | — | 120 | 114 | 104 | 52 | 41 | |
| 50 | — | 150 | 143 | 130 | 65 | 52 | |
| 60 | — | 177 | 169 | 154 | 77 | 62 | |
| 75 | — | 221 | 211 | 192 | 96 | 77 | |
| 100 | — | 285 | 273 | 248 | 124 | 99 | |
| 125 | — | 359 | 343 | 312 | 156 | 125 | |
| 150 | — | 414 | 396 | 360 | 180 | 144 | |

**Calculate branch circuit size, overcurrent protection, motor overload device size, and thermal protection.**

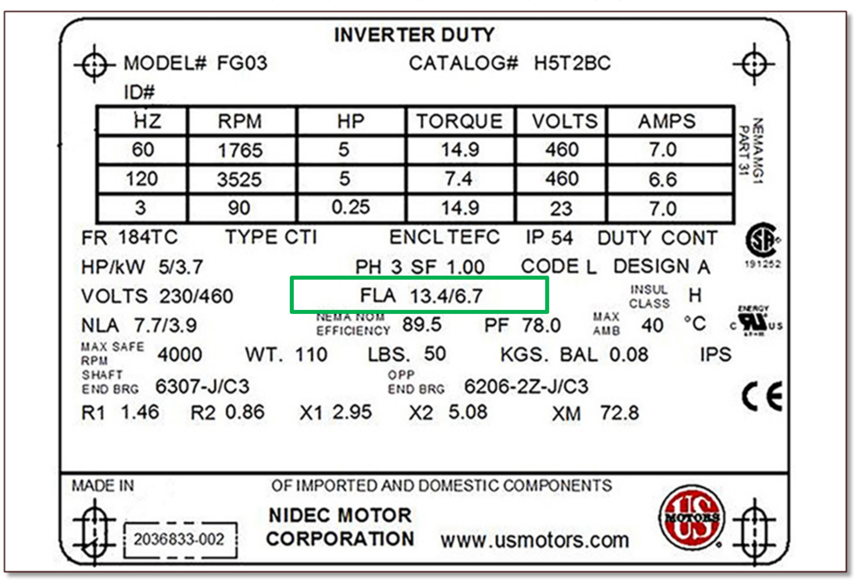
- Using Table 430.250
- States that a 5HP, 3 phase 460 volt motor will draw _______ amps full load current.
- How many amps did the nameplate say? ________
- Section 430.22 tells us we now have to ______________________________ .
- We must now go to Table 310.15(b)(16)and find a conductor with insulation of THWN that can carry our motor load, the size is _______.







# Calculation Exercise



Motors

**Calculate branch circuit size, overcurrent protection, motor overload device size, and thermal protection.**

- Using Table 430.250
- States that a 5HP, 3 phase 460 volt motor will draw ___7.6__ amps full load current.
- How many amps did the nameplate say? ________
- Section 430.22 tells us we now have to ______________________________ .
- We must now go to Table 310.15(b)(16)and find a conductor with insulation of THWN that can carry our motor load, the size is _______.

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65

Motors

**Calculate branch circuit size, overcurrent protection, motor overload device size, and thermal protection.**

***430.22 Single Motor.*** *Conductors that supply a single motor used in a continuous duty application shall have an ampacity of not less than 125 percent of the motor full-load current rating, as determined by 430.6(A)(1), or not less than specified in 430.22(A) through (G).*

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66

Motors

**Calculate branch circuit size, overcurrent protection, motor overload device size, and thermal protection.**

- Using Table 430.250
- States that a 5HP, 3 phase 460 volt motor will draw ___7.6__ amps full load current.
- How many amps did the nameplate say? ________
- Section 430.22 tells us we now have to ______________________________ .
- We must now go to Table 310.15(b)(16)and find a conductor with insulation of THWN that can carry our motor load, the size is _______.

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67

Motors

# Conductor Size - Table 310.15(B)16

| Size AWG or kcmil | Temperature Rating of Conductor [See Table 310.104(A).] | | | | | | Size AWG or kcmil |
|---|---|---|---|---|---|---|---|
| | 60°C (140°F) | 75°C (167°F) | 90°C (194°F) | 60°C (140°F) | 75°C (167°F) | 90°C (194°F) | |
| | Types TW, UF | Types RHW, THHW, THW, THWN, XHHW, USE, ZW | Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2 | Types TW, UF | Types RHW, THHW, THW, THWN, XHHW, USE | Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2 | |
| | COPPER | | | ALUMINUM OR COPPER-CLAD ALUMINUM | | | |
| 18** | — | — | 14 | — | — | — | — |
| 16** | — | — | 18 | — | — | — | — |
| 14** | 15 | 20 | 25 | — | — | — | — |
| 12** | 20 | 25 | 30 | 15 | 20 | 25 | 12** |
| 10** | 30 | 35 | 40 | 25 | 30 | 35 | 10** |
| 8 | 40 | 50 | 55 | 35 | 40 | 45 | 8 |
| 6 | 55 | 65 | 75 | 40 | 50 | 55 | 6 |

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68

Motors

**Calculate branch circuit size, overcurrent protection, motor overload device size, and thermal protection.**

- Using Table 430.250
- States that a 5HP, 3 phase 460 volt motor will draw ___7.6__ amps full load current.
- How many amps did the nameplate say? ___6.7____
- Section 430.22 tells us we now have to ______________________________ .
- We must now go to Table 310.15(b)(16)and find a conductor with insulation of THWN that can carry our motor load, the size is _______.



Motors

**Calculate branch circuit size, overcurrent protection, motor overload device size, and thermal protection.**

- Table 430.52 will provide information about the proper size of molded case breaker we need.
- We had a full load current of 7.6 amps according to Table 430.250. We must increase this number by: ________%.
- The calculated number is _________ amps.
- Now we must look at 240.6 and locate the appropriate overcurrent device in accordance with 430.52 (C) (1) Exc. #1. The size of the breaker is _________

Motors

**Calculate branch circuit size, overcurrent protection, motor overload device size, and thermal protection.**

**Table 430.52 Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices**

| | Percentage of Full-Load Current | | | |
|---|---|---|---|---|
| Type of Motor | Nontime Delay Fuse[1] | Dual Element (Time-Delay) Fuse[1] | Instantaneous Trip Breaker | Inverse Time Breaker[2] |
| Single-phase motors | 300 | 175 | 800 | 250 |
| AC polyphase motors other than wound-rotor | 300 | 175 | 800 | 250 |
| Squirrel cage — other than Design B energy-efficient | 300 | 175 | 800 | 250 |
| Design B energy-efficient | 300 | 175 | 1100 | 250 |
| Synchronous[3] | 300 | 175 | 800 | 250 |
| Wound-rotor | 150 | 150 | 800 | 150 |
| DC (constant voltage) | 150 | 150 | 250 | 150 |



71

Motors

**Calculate branch circuit size, overcurrent protection, motor overload device size, and thermal protection.**

- Table 430.52 will provide information about the proper size of molded case breaker we need. We had a full load current of 7.6 amps according to Table 430.250.
- We had a full load current of 7.6 amps according to Table 430.250. We must increase this number by: ________%.
- The calculated number is __________ amps.
- Now we must look at 240.6 and locate the appropriate overcurrent device in accordance with 430.52 (C) (1) Exc. #1. The size of the breaker is __________



72

Motors

## Fuse Size

**Table 240.6(A) Standard Ampere Ratings for Fuses and Inverse Time Circuit Breakers**

| Standard Ampere Ratings | | | | |
|---|---|---|---|---|
| 15 | 20 | 25 | 30 | 35 |
| 40 | 45 | 50 | 60 | 70 |
| 80 | 90 | 100 | 110 | 125 |
| 150 | 175 | 200 | 225 | 250 |
| 300 | 350 | 400 | 450 | 500 |
| 600 | 700 | 800 | 1000 | 1200 |
| 1600 | 2000 | 2500 | 3000 | 4000 |
| 5000 | 6000 | — | — | — |

 73

73

Motors

## Calculate branch circuit size, overcurrent protection, motor overload device size, and thermal protection.

- Table 430.52 will provide information about the proper size of molded case breaker we need. We had a full load current of 7.6 amps according to Table 430.250.
- We had a full load current of 7.6 amps according to Table 430.250. We must increase this number by: ________%.
- The calculated number is _________ amps.
- Now we must look at 240.6 and locate the appropriate overcurrent device in accordance with 430.52 (C) (1) Exc. #1. The size of the breaker is _________

 74

74

## Size the Overloads

- Let’s begin with 430.32 (A) (1)

  A separate overload device that is responsive to motor current. This device shall be selected to trip or shall be rated at no more than the following percent of the motor nameplate full load current rating:
- Our motor had a FLA on the nameplate of 6.7 amps. The service factor of our motor was 1.0, based on this, our overloads will be _____% of 6.7.
- Which will result in a heater size of ____________________.

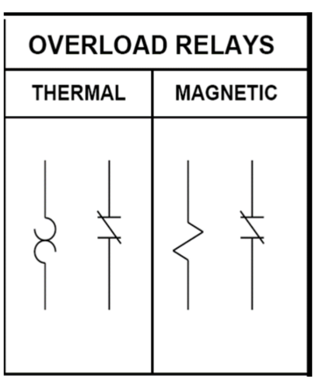
| | |
|---|---|
| Motors with a marked service factor 1.15 or greater | 125% |
| Motors with a marked temperature rise 40°C or less | 125% |
| All other motors | 115% |

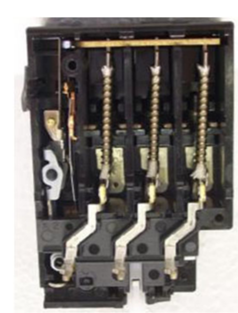






## Size the Overloads



Motors

# Types of Motors

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77

Motors

## Types of Motors

*AC*

- Single-phase
  - Split Phase
  - Commutator
- Three-phase
  - Induction
  - Synchronous
  - Wire Wound

*DC*

- Series
- Shunt
- Compound
- Permanent Magnet

***Universal Motor***

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78

# Types of Motors

| Motor Type | Start Torque | Speed Control | Size Horsepower | Typical Applications |
|---|---|---|---|---|
| **Single Phase** | | | | |
| Split Phase | Low | Constant | Fractional | Small Pumps |
| Capacitor Start | Medium | Constant* | Up to 3 HP | Refrigerators |
| Perm. Split Cap | Very Low | Constant* | Up to 5 HP | Blowers |
| Two Value Cap. | High | Constant* | Up to 10 HP | Compressors |
| Repulsion | High | Variable | Up to 3 HP | Printing Press |
| Rep. Start Ind. Run | High | Constant | Up to 10 HP | Compressors |
| Repulsion Induction | High | Constant | Up to 10 HP | Pumps |
| Shaded Pole | Very Low | Constant* | Fractional | Fans |
| Universal | High | Variable | Fractional | Power Tools |

***Multiple fixed speeds available through separate windings or consequent poles.**







# Types of Motors

| Motor Type | Start Torque | Speed Control | Size Horsepower | Typical Applications |
|---|---|---|---|---|
| **Three Phase** | | | | |
| Squirrel Cage | Low/High | Constant* | All Sizes | Machine Tools |
| Wound Rotor | Medium | Variable | To 1,000 HP | Cranes |
| Synchronous | Very Low | Constant* | To 5,000 HP | Slow Heavy Loads |

| Starting Torque | Percent of Full Load Torque |
|---|---|
| Very Low | Below 100% |
| Low | 100% - 200% |
| Medium | 200% - 300% |
| High | 300% - 400% |
| Very High | Above 400% |

Motors

# Types of Motors

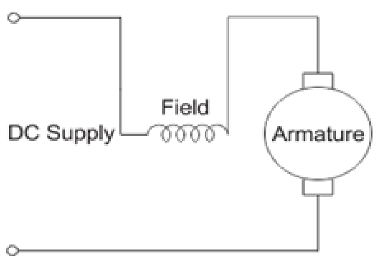
| Motor Type | Start Torque | Speed Control | Size Horsepower | Typical Applications |
|---|---|---|---|---|
| Series | Very High | Variable | Up to 200 HP | Traction Loads |
| Shunt | Medium | Constant/Adjustable | Up to 200 HP | Elevators |
| | | | | |
| Compound | High | Constant/Variable | Up to 200 HP | Conveyors |
| | | | | |
| Permanent Magnet | Medium | Constant/Adjustable | Up to 5 HP | Golf Carts |

| Starting Torque | Percent of Full Load Torque |
|---|---|
| Very Low | Below 100% |
| Low | 100% - 200% |
| Medium | 200% - 300% |
| High | 300% - 400% |
| Very High | Above 400% |

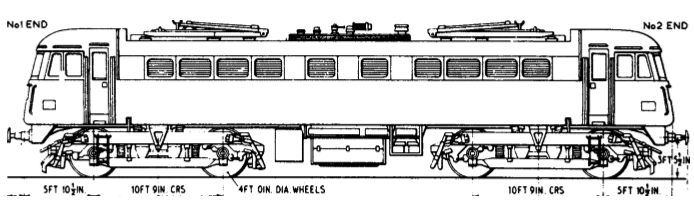


Motors

# DC Series Motor

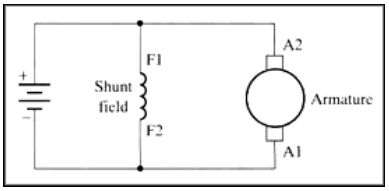



The load on a series motor determines the current in the armature and series field and hence the flux per pole. On very small loads, the flux set up by the main poles is very weak and the machine has to run at a very high speed in order to generate a back e.m.f. of a magnitude similar to that of the supply voltage. This speed may be in excess of that for which the machine was designed and mechanical damage may result due to the large centrifugal forces.



Motors

# DC Shunt Motor




Because of their self-regulating speed capabilities, DC shunt motors are ideal for applications where precise speed control is required.

They cannot produce high starting torque, so the load at startup must be small.

Applications

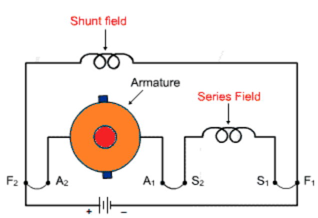
- machine tools such as lathes and grinders,
- industrial equipment such as fans and compressors.

 83

83

Motors

# DC Compound Motor




Schematic diagram of dc compound motor

Compound motor - high starting torque and nearly constant speed.

Because of that compound motors are used where we require high starting torque and constant speed.

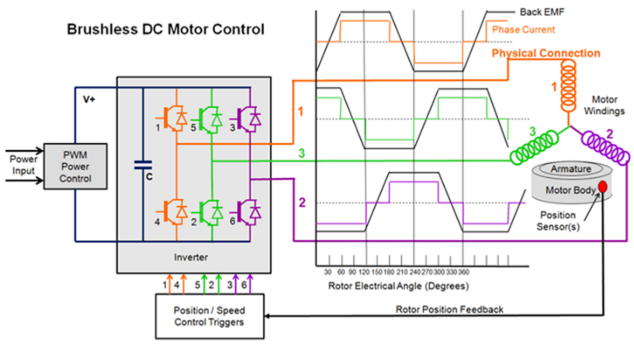
A compound motor is used in Presses, Shears, Conveyors, Elevators, Rolling Mills, Heavy Planners, etc.

 84

84

Motors

## Brushless DC Motor




Brushless DC motors (BLDC) are used for a wide variety of application requirements such as varying loads, constant loads and positioning applications in the fields of industrial control, automotive, aviation, automation systems, health care equipments, etc. Some specific applications of BLDC motors are :

- Computer hard drives and DVD/CD players
- Electric vehicles, hybrid vehicles, and electric bicycles
- Industrial robots, CNC machine tools, and simple belt driven systems
- Washing machines, compressors and dryers
- Fans, pumps and blowers.

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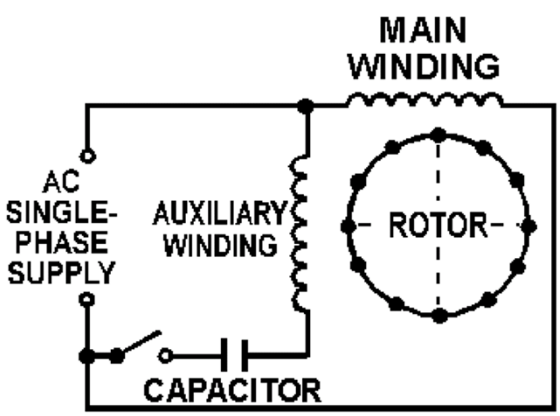
85

Motors

## Single Phase AC Motor




Good applications for split-phase motors include small grinders, small fans and blowers, and other low starting torque applications with power needs from 1/20 to 1/3 hp. Avoid applications requiring high cycle rates or high torque.

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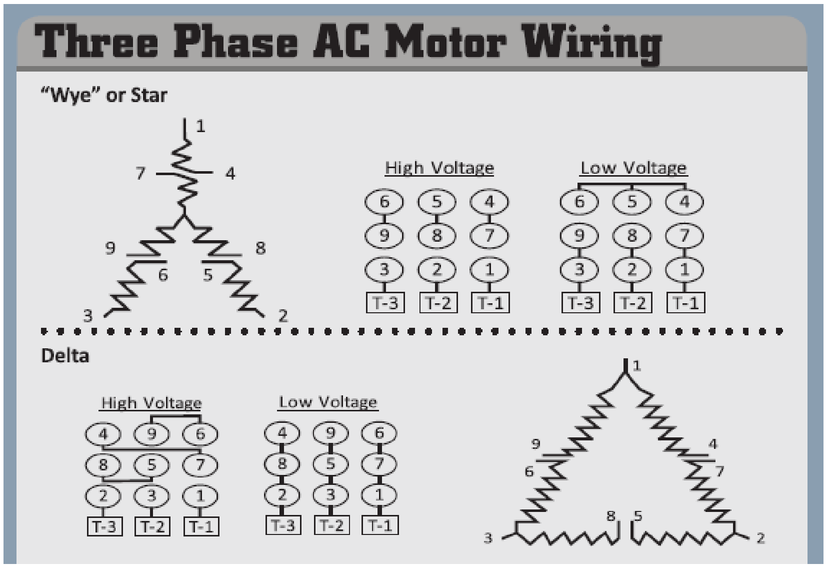
86

Motors

# Three Phase AC Motors

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87

Motors

# Three Phase AC Motors

## General Motor Rules

When an AC motor is energized, a high inrush current occurs that can reach 4 to 8 times the normal current. Due to this high starting current, the motor and motor circuit conductors are allowed to be protected by fuses and circuit breakers and values that are higher than the actual motor and conductor ampere ratings. These larger valued overcurrent devices do not provide overload protection. Motor overload protection is calculated from the motor nameplate data.

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88

Motors

## Three Phase AC Motors

**Motor Rules**

- Use FLC (Full-Load Current) from NEC Tables instead of motor nameplate data.
- Branch Circuit Conductors – use 125% of FLC (Full-Load Current) to find proper conductor size
- Branch Circuit OCP (Overcurrent Protection) Size – Use percentages given by NEC Table 430.52
- Feeder Conductor Size – 125% of largest motor and the sum of the rest.
- Feeder OCP (Overcurrent Protection) – Use the largest OCP plus the rest of the full-load currents.

 89

89

Motors

## Three Phase AC Motors

**Branch Circuit Example**

- 25 HP (Squirrel Cage), 460 VAC, 60 HZ, 3 PH, 30 FLA (Full-Load Amps), Design B, SF 1.15, FLC (Full-Load Current) = 34 A.
- Branch Circuit Conductor Sizing – 125% of FLC, 34 x 125% = 42.5; #8 AWG (Minimum)
- Branch Circuit OCP Sizing – 175% of FLC (Dual Element Fuse), 34 x 175% = 59.6, 60 amps (Maximum)

 90

90

## Three Phase AC Motors

| Motor Overload Protection |
| --- |
| Motors with a Service Factor (SF) of 1.15 or higher, use 125% of nameplate FLA (Full-Load Amps). For all others, use 115% of motor nameplate FLA (Full-Load Amps) |



91



## Three Phase AC Motors

### Single Motor Overload Example

- 30 Amps (FLA) x 125% = 37.5 A
- For proper motor protection, select the overload protection for 37.5 Amperes. If it is not available, select the next larger size - 430.32(A)(1) and 430.32(C). But do not exceed the maximum percentages allowed.



92

Motors

A specification which indicates the current amperage being drawn by an electric motor when it is "locked up", i.e., not turning.

*TABLE 430.7(B) Locked-Rotor Indicating Code Letters*

| Code Letter | Kilovolt-Amperes per Horsepower with Locked Rotor |
|---|---|
| A | 0–3.14 |
| B | 3.15–3.54 |
| C | 3.55–3.99 |
| D | 4.0–4.49 |
| E | 4.5–4.99 |
| F | 5.0–5.59 |
| G | 5.6–6.29 |
| H | 6.3–7.09 |
| J | 7.1–7.99 |
| K | 8.0–8.99 |
| L | 9.0–9.99 |
| M | 10.0–11.19 |
| N | 11.2–12.49 |
| P | 12.5–13.99 |
| R | 14.0–15.99 |
| S | 16.0–17.99 |
| T | 18.0–19.99 |
| U | 20.0–22.39 |
| V | 22.4 and up |


 93

93

Motors

## Calculation Example

A 20-hp, 460-V, 3-phase motor has a nameplate kilovolt-ampere code letter G. Determine the maximum locked-rotor current for this motor.

 94

94

**Solution**

*Step 1.* Use Table 430.7(B) to find the maximum value in the range for code letter G, which is 6.29 kVA per horsepower.

*Step 2.* Use the following formula to find the maximum locked-rotor current:

Locked-rotor kVA = motor hp × maximum code letter value = 20 × 6.29 = 125.8 kva

Locked-rotor current = locked rotor kva divided by square root of 3 times kv
For 460 V (460 V = 0.46 kV), 125.8 divided by 1.73 times .46 = 158 Amps

The maximum locked-rotor current for a 20-hp, 460-V motor with code letter G is 158 A when the system voltage is 460 V.



95



# Motor Disconnects



96

## Motor Disconnects

**Part IX. Disconnecting Means**
**430.101 General.** Part IX is intended to require disconnecting means capable of disconnecting motors and controllers from the circuit.

**430.102 Location.**
**(A) Controller.** An individual disconnecting means shall be provided for each controller and shall disconnect the controller. The disconnecting means shall be located in sight from the controller location.

*Exception No. 1: For motor circuits over 1000 volts, nominal, a controller disconnecting means lockable in accordance with 110.25 shall be permitted to be out of sight of the controller, provided that the controller is marked with a warning label giving the location of the disconnecting means.*







## Motor Disconnects

**Part IX. Disconnecting Means**
**430.101 General.** Part IX is intended to require disconnecting means capable of disconnecting motors and controllers from the circuit.

**430.102 Location.**
**(A) Controller.** An individual disconnecting means shall be provided for each controller and shall disconnect the controller. The disconnecting means shall be located in sight from the controller location.

*Exception No. 2: A single disconnecting means shall be permitted for a group of coordinated controllers that drive several parts of a single machine or piece of apparatus. The disconnecting means shall be located in sight from the controllers, and both the disconnecting means and the controllers shall be located in sight from the machine or apparatus.*

Motors

## Motor Disconnects

**Part IX. Disconnecting Means**
**430.101 General.** Part IX is intended to require disconnecting means capable of disconnecting motors and controllers from the circuit.

**430.102 Location.**
**(A) Controller.** An individual disconnecting means shall be provided for each controller and shall disconnect the controller. The disconnecting means shall be located in sight from the controller location.
*Exception No. 3: The disconnecting means shall not be required to be in sight from valve actuator motor (VAM) assemblies containing the controller where such a location introduces additional or increased hazards to persons or property and conditions (a) and (b) are met.*
*(a) The valve actuator motor assembly is marked with a warning label giving the location of the disconnecting means.*
*(b) The disconnecting means is lockable in accordance with 110.25.*

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99

Motors

**(B) Motor.** A disconnecting means shall be provided for a motor in accordance with (B)(1) or (B)(2).
**(1) Separate Motor Disconnect.** A disconnecting means for the motor shall be located in sight from the motor location and the driven machinery location.
**(2) Controller Disconnect.** The controller disconnecting means required in accordance with 430.102(A) shall be permitted to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location.

*Exception to (1) and (2): The disconnecting means for the motor shall not be required under either condition (a) or condition (b), which follow, provided that the controller disconnecting means required in 430.102(A) is lockable in accordance with 110.25.*
*(a) Where such a location of the disconnecting means for the motor is impracticable or introduces additional or increased hazards to persons or property*

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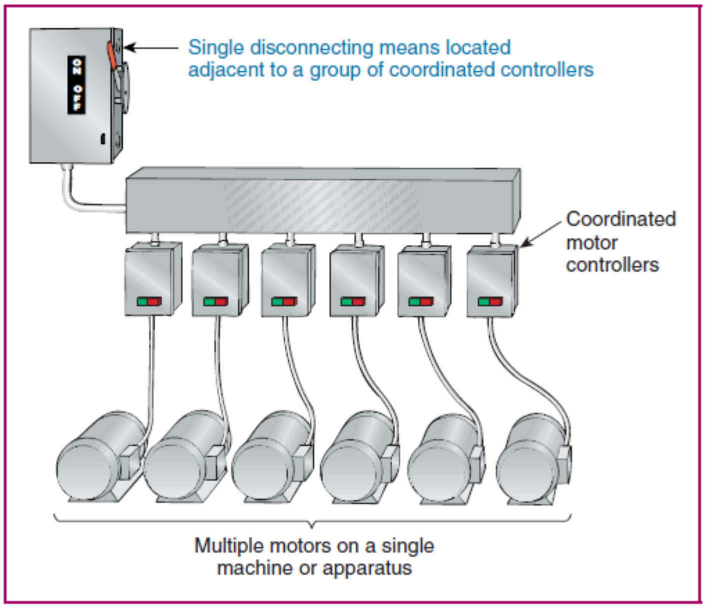
100

Motors

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101

Motors

**430.103 Operation.** The disconnecting means shall open all ungrounded supply conductors and shall be designed so that no pole can be operated independently. The disconnecting means shall be permitted in the same enclosure with the controller. The disconnecting means shall be designed so that it cannot be closed automatically.

**430.104 To Be Indicating.** The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position.

**430.105 Grounded Conductors.** One pole of the disconnecting means shall be permitted to disconnect a permanently grounded conductor, provided the disconnecting means is designed so that the pole in the grounded conductor cannot be opened without simultaneously disconnecting all conductors of the circuit.

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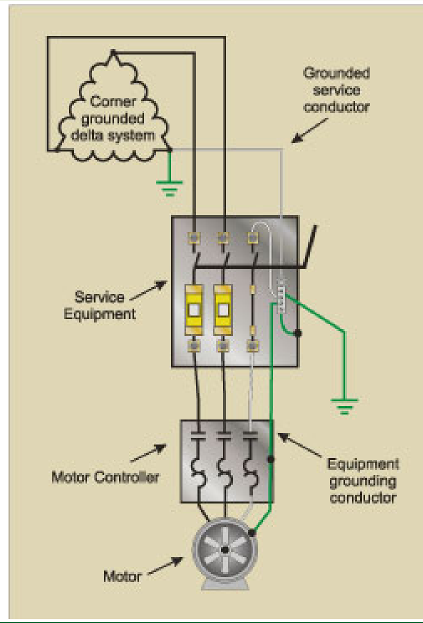
102

Motors

# Motor Control

***430.105 In Grounded Conductors.*** *One pole of the controller shall be permitted to be placed in a permanently grounded conductor, provided the controller is designed so that the pole in the grounded conductor cannot be opened without simultaneously opening all conductors of the circuit.*





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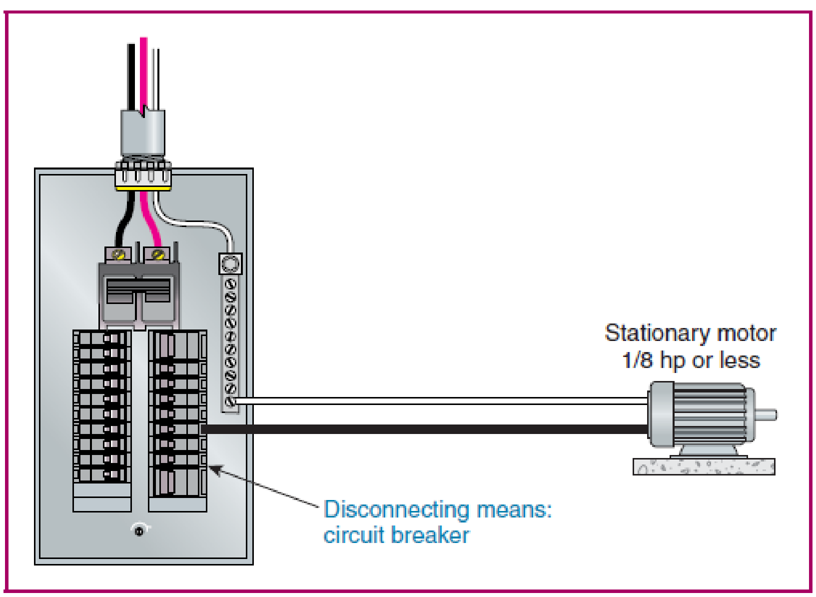

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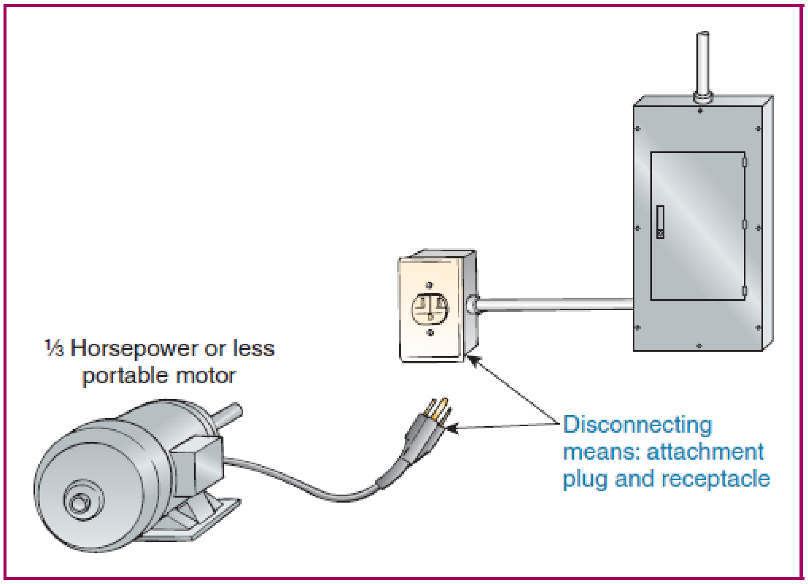


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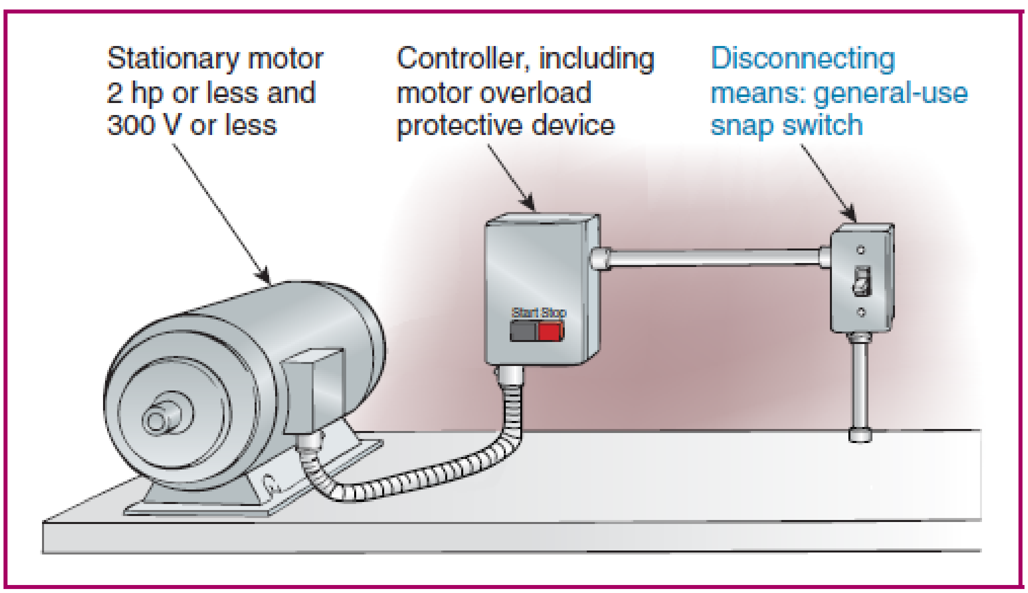
105

Motors

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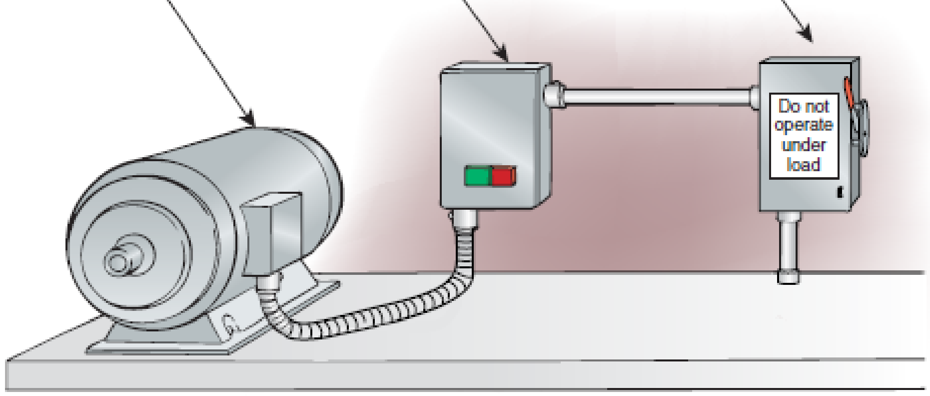
106

Motors

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107

Motors

## Feeder and Branch Circuit Sizes

**430.24 Several Motors or a Motor(s) and Other Load(s).** Conductors supplying several motors, or a motor(s) and other load(s), shall have an ampacity not less than the sum of each of the following:

(1) 125 percent of the full-load current rating of the highest rated motor, as determined by 430.6(A)

(2) Sum of the full-load current ratings of all the other motors in the group, as determined by 430.6(A)

(3) 100 percent of the noncontinuous non-motor load

(4) 125 percent of the continuous non-motor load.

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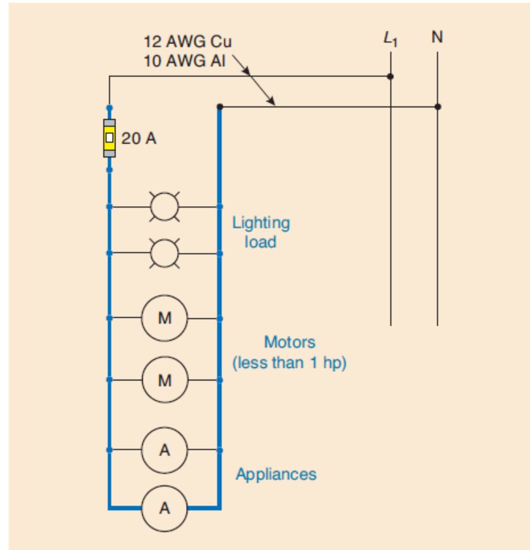
108

Motors

**430.25 Multimotor and Combination-Load Equipment.** The ampacity of the conductors supplying multimotor and combination load equipment shall not be less than the minimum circuit ampacity marked on the equipment in accordance with 430.7(D). Where the equipment is not factory-wired and the individual nameplates are visible in accordance with 430.7(D)(2), the conductor ampacity shall be determined in accordance with 430.24.




 109

109

Motors

**430.26 Feeder Demand Factor.** Where reduced heating of the conductors results from motors operating on duty-cycle, intermittently, or from all motors not operating at one time, the authority having jurisdiction may grant permission for feeder conductors to have an ampacity less than specified in 430.24, provided the conductors have sufficient ampacity for the maximum load determined in accordance with the sizes and number of motors supplied and the character of their loads and duties.

 110

110

Motors

## Motor Control

***(A) Stationary Motor of 1⁄8 Horsepower or Less.*** *For a stationary motor rated at 1⁄8 hp or less that is normally left running and is constructed so that it cannot be damaged by overload or failure to start, such as clock motors and the like, the branch circuit disconnecting means shall be permitted to serve as the controller.*

***(B) Portable Motor of 1⁄3 Horsepower or Less.*** *For a portable motor rated at 1⁄3 hp or less, the controller shall be permitted to be an attachment plug and receptacle or cord connector.*

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111

Motors

## Motor Control

***(1) Horsepower Ratings****.* *Controllers, other than inverse time circuit breakers and molded case switches, shall have horsepower ratings at the application voltage not lower than the horsepower rating of the motor.*

**AC Motor Data**

| Horsepower | Voltage | Full-Load Current | Maximum Allowable Overcurrent Protection Device (Amps) | | | Wire Size * | Conduit Size (EMT) Max 3 Current Carrying Conductors | Motor Starter Size |
|---|---|---|---|---|---|---|---|---|
| | | | Nontime Delay Fuse | Duel Element (time-delay fuse) | Inverse Time (circuit breaker) | | | |
| 1/2 | 230V | 2.2 | 6 | 6 | 15 | 14 | 1/2 | 0 |
| | 460V | 1.1 | 3 | 3 | 15 | 14 | 1/2 | 0 |
| 3/4 | 230V | 3.2 | 10 | 6 | 15 | 14 | 1/2 | 0 |
| | 460V | 1.6 | 6 | 3 | 15 | 14 | 1/2 | 0 |
| 1 | 230V | 4.2 | 15 | 10 | 15 | 14 | 1/2 | 0 |
| | 460V | 2.1 | 6 | 6 | 15 | 14 | 1/2 | 0 |
| 1 1/2 | 230V | 6 | 20 | 10 | 15 | 14 | 1/2 | 0 |
| | 460V | 3 | 10 | 6 | 15 | 14 | 1/2 | 0 |
| 2 | 230V | 6.8 | 20 | 15 | 20 | 14 | 1/2 | 0 |
| | 460V | 3.4 | 10 | 6 | 10 | 14 | 1/2 | 0 |
| 3 | 230V | 9.6 | 30 | 20 | 25 | 14 | 1/2 | 0 |
| | 460V | 4.8 | 15 | 10 | 15 | 14 | 1/2 | 0 |
| 5 | 230V | 15.2 | 50 | 30 | 40 | 12 | 1/2 | 1 |
| | 460V | 7.6 | 25 | 15 | 20 | 14 | 1/2 | 0 |
| 7 1/2 | 230V | 22 | 70 | 40 | 60 | 10 | 1/2 | 1 |
| | 460V | 11 | 35 | 20 | 30 | 14 | 1/2 | 1 |

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112

Motors

# Motor Control

***(2) Circuit Breaker.*** *A branch-circuit inverse time circuit breaker rated in amperes shall be permitted as a controller for all motors. Where this circuit breaker is also used for overload protection, it shall conform to the appropriate provisions of this article governing overload protection.*


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113

Motors

# Motor Control

***430.88 Adjustable-Speed Motors.*** *Adjustable-speed motors that are controlled by means of field regulation shall be equipped and connected so that they cannot be started under a weakened field.*

*Exception: Starting under a weakened field shall be permitted where the motor is designed for such starting.*


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114

Motors

# Motor Control

***430.89 Speed Limitation****. Machines of the following types shall be provided with speed-limiting devices or other speed limiting means:*
*(1) Separately excited dc motors*
*(2) Series motors*
*(3) Motor-generators and converters that can be driven at excessive speed from the dc end, as by a reversal of current or decrease in load*

*Exception: Separate speed-limiting devices or means shall not be required under either of the following conditions:*
*(1) Where the inherent characteristics of the machines, the system, or the load and the mechanical connection thereto are such as to safely limit the speed*
*(2) Where the machine is always under the manual control of a qualified operator*

 115

115

Motors

# Motor Control Centers

**430.94 Overcurrent Protection.** Motor control centers shall be provided with overcurrent protection in accordance with Parts I, II, and VIII of Article 240. The ampere rating or setting of the overcurrent protective device shall not exceed the rating of the common power bus. This protection shall be provided by:
(1) an overcurrent protective device located ahead of the motor control center or
(2) a main overcurrent protective device located within the motor control center.

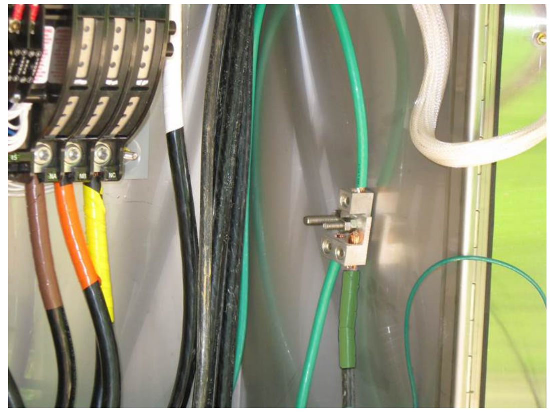
 116

116

Motors

## Motor Control Centers

**430.96 Grounding.** Multi-section motor control centers shall be connected together, with an equipment grounding conductor or an equivalent equipment grounding bus sized in accordance with Table 250.122. Equipment grounding conductors shall be connected to this equipment grounding bus or to a grounding termination point provided in a single-section motor control center.



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117

Motors

## Table 250.122

| Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes) | Size (AWG or kcmil) Copper | Aluminum or Copper-Clad Aluminum* |
|---|---|---|
| 15 | 14 | 12 |
| 20 | 12 | 10 |
| 60 | 10 | 8 |
| 100 | 8 | 6 |
| 200 | 6 | 4 |
| 300 | 4 | 2 |
| 400 | 3 | 1 |
| 500 | 2 | 1/0 |
| 600 | 1 | 2/0 |
| 800 | 1/0 | 3/0 |
| 1000 | 2/0 | 4/0 |
| 1200 | 3/0 | 250 |
| 1600 | 4/0 | 350 |

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118

Motors

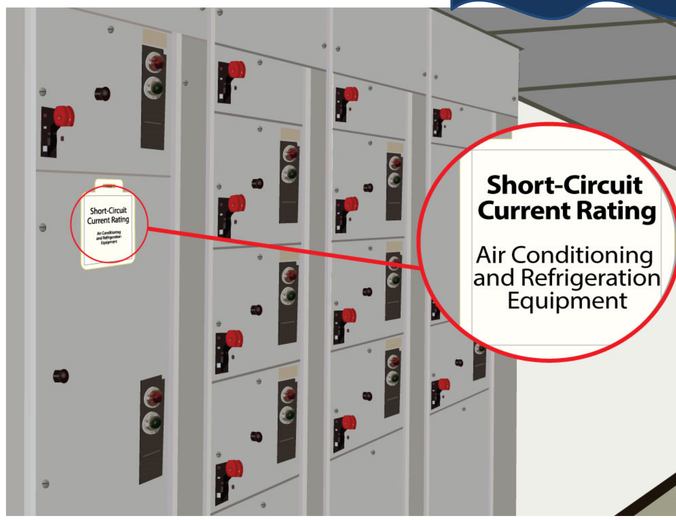
NC Amendment

## 430.99 Motor Control Centers. Available Fault Current.

**NC DELETES 430.99**

- **The available short-circuit current at the equipment IS NOT REQUIRED to be made available to those authorized to inspect the installation.**

**The MCC short-circuit current rating must still be marked on the equipment.**

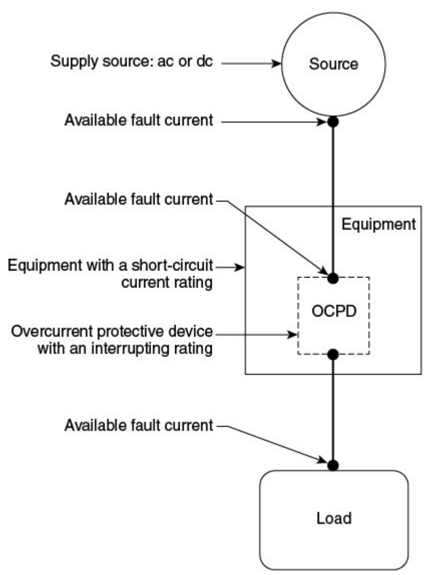





119

Motors

## Available Fault Current




Fault Current, Available (Available Fault Current)

The largest amount of current capable of being delivered at a point on the system during a short-circuit condition.



120

# Thank you from all of us at JADE Learning!

## Questions?

Call: 1-800-443-5233

Email: registrar@jadelearning.com







## Common Questions and Answers

- **How many classroom hours do I need?**
  - 4 classroom hours per year for I, U, L - 8 total
  - 2 classroom hours per year for SP -4 total
- **Can these hours be transferred to other states?**
  - In some cases, yes. Call or email the office to find out.
- **If I have not yet submitted payment for this class, how do I pay?**
  - Call or email the office – we can take your payment over the phone.
- **How are my hours reported?**
  - Your hours are reported electronically, once payment has been received, and you have signed in on the class roster. Make sure to sign in! If your name is not on the sign in sheet, write it in and sign in next to it.