Conductor Ampacity and Derating

A. UNDERSTANDING CONDUCTOR AMPACITY

Comparison of Water and Electrical Flow

		Water	Electrical
1.	Source of Supply	Water Pump	Generator
2.	Pathway	Water Pipe	Conductor
3.	Pressure	Pounds/square inch	Voltage
4.	Rate of Flow	Gallons/minute	Amperes
5.	Opposition to Flow	Restriction	Resistance
6.	Consumption or Load	Drinking, Sanitation, Irrigation	Heat, Light, and Power

Conductor: The material used to establish current paths between components in electrical and electronic circuits. The most common conductor materials used in electrical work are copper and aluminum.

All materials possess, in varying degrees, a property referred to as conductance. Good conductors, such as silver and copper, have high values of conductance. Poor conductors or insulators, such as rubber and glass, have very low values of conductance. The unit of measurement for conductance is the mho. If a voltage of one volt is applied to a conductor having a conductance of one mho, a current of one ampere will flow through the conductor.

Using silver at a reference point of 100% conductivity (which it is not exactly), you can see how it compares with some other metals:

Silver	100%	Iron	16%
Copper	98%	Lead	15%
Gold	78%	Tin	9%
Aluminum	61%	Nickel	7%
Zinc	30%	Mercury	1%

Ampere: The practical unit of measurement of electrical current flow. The amount of electric current that will flow through one ohm of resistance under a pressure of one volt.

→ The rate of flow of one coulomb of charge past a point in a circuit in one second. A coulomb is defined as the charge produced by an accumulation of 6.28×10^{18} or 6,280,000,000,000,000,000 electrons. Therefore, an ampere is the flow of 6.28 million, million, million electrons per second.

→ It has been internationally agreed (recommended by the Chicago International Electrical Congress of 1893 and legalized by Act of Congress in 1894) that the ampere be defined as that "unvarying current, which, when passed through a solution of nitrate silver in water in accordance with standard specifications, deposits silver at the rate of one thousand one hundred and eighteen millionths (0.001118) of a gram per second.

C. DETERMINING CONDUCTOR AMPACITY

► **According to 110.5, conductors are considered to be copper unless otherwise indicated.**

► **Three steps to determine conductor ampacity** are: 1) Locate conductor type and size in Tables, 2) Multiply ampacity by Ambient Temperature Correction Factor, if applicable, and 3) Multiply ampacity by percent of value for more than three conductors in a raceway or cable, if applicable.

1. **Locate wire type and size in Tables 310.15 (B)(16) through (21)** including 310.15(B)(7) for 120/240 Volts, 3-Wire, Single-Phase Dwelling Services and Feeders, Table 400.5(A)(1) and Table 400.5(A)(2) for Flexible Cords and Cables, and Table 402.5 for Fixture Wires.

   NOTE: Most terminations are normally designed only for 60°C (140°F) or 75°C (167°F) maximum temperatures, although some are now being designed for 90°C (194°F). Therefore, the higher rated ampacities for conductors of 90°C (194°F), 110°C (230°F) etc., cannot be utilized unless the terminals at which the conductors terminate have comparable ratings; e.g., a 1 AWG THHN copper conductor can serve a load of 110-amps or less on 60°C terminals, a 130-amp load or less on 75°C terminals, and a 145- amp load or less on 90°C terminals.

   110.14(C) Temperature Limitations
   The temperature rating associated with the ampacity of a conductor shall be selected and coordinated so as not to exceed the lowest temperature rating of any connected termination, conductor, or device. Conductors with temperature ratings higher than specified for terminations shall be permitted to be used for ampacity adjustment, correction, or both.

   (1) Equipment Provisions. The determination of termination provisions of equipment shall be based on 110.14 (C)(1)(a) or (C)(1)(b). Unless the equipment is listed and marked otherwise, conductor ampacities used in determining equipment termination provisions shall be based on Table 310.15(B)(16) as appropriately modified by 310.15(B)(7).

   (a) Termination provisions of equipment for circuits rated 100 amperes or less, or marked for 14 AWG through 1 AWG conductors, shall be used only for one of the following:
      (1) Conductors rated 60°C (140°F)
      (2) Conductors with higher temperature ratings, provided ampacity of such conductors is determined based on the 60°C (140°F) ampacity of the conductor size used.
      (3) Conductors with higher temperature ratings if the equipment is listed and identified for use with such conductors.
      (4) For motors marked with design letters B, C, or D, conductors having an insulation rating of 75°C (167°F) or higher shall be permitted to be used provided the ampacity of such conductors does not exceed the 75°C (167°F) ampacity.

   (b) Termination provisions of equipment for circuits rated over 100 amperes, or marked for conductors larger than 1 AWG, shall be used only for one of the following:

(1) Conductors rated 75°C (167°F)

(2) Conductors with higher temperature ratings, provided the ampacity of such conductors does not exceed the 75°C (167°F) ampacity of the conductor sized used, or up to their ampacity if the equipment is listed and identified for use with such conductor.

(2) Separate Connector Provisions. Separately installed pressure connectors shall be used with conductors at the ampacities not exceeding the ampacity at the listed and identified temperature rating of the connector.

Informational Note: With respect to 110.14 (C)(1) and (C)(2), equipment markings or listing information may additionally restrict the sizing and temperature ratings of connected conductors.

2. **Multiply Ampacity by Ambient Temperature Correction Factor** if applicable, utilizing Table 310.15(B)(2)(a) for 30°C rating and Table 310.15(B)(2)(b) for 40°C rating. Where raceways or cables are exposed to direct sunlight on or above rooftops, raceways or cable shall be installed a minimum distance above the roof to the bottom of the raceway or cable of 7/8-in. Where the distance above the roof to the bottom of the raceway is less than 7/8-in., a temperature adder of 33ºC (60ºF) shall be added to the outdoor temperature to determine the applicable ambient temperature for application of the correction factors in Table 310.15(B)(2)(a) or Table 310.15(B)(2)(b).

3. **Multiply ampacity by percent of value for more than three conductors in a raceway or cable**
   310.15(B)(3)(a) and Table 310.15(B)(3)(a) or 400.5 and Table 400.5(A)(3) for flexible cords and cables.

1. Problem: What is the ampacity of (3) 1/0 AWG THHN copper current-carrying conductors installed in E.M.T.?

Solution: Table 310.15(B)(16) (90°C column)

Answer: 170 amps

2. Problem: What is the ampacity of (3) 250 kcmil XHHW aluminum current-carrying conductors installed in PVC and used for an underground feeder?

Solution: Table 310.104(A), Table 310.15(B)(16) (75°C column for wet location)

Answer: 205 amps

3. Problem: What is the ampacity of (3) 12 AWG THHN copper current-carrying conductors installed in E.M.T. in an ambient temperature of 120°F?

Solution: 30 amps × .82 = 24.6 amps - Table 310.15(B)(16) (90°C column) and Ambient Temperature Correction Factor from Table 310.15(B)(2)(a)

Answer: 25 amps (Note: The overcurrent protection for 12 AWG shall not generally exceed 20 amperes— 240.4 (D))

4. Problem: What is the ampacity of (6) 6 AWG THW copper current-carrying conductors installed in Rigid Metal Conduit?

Solution: 65 amps × 80% = 52 amps - Table 310.15(B)(16) (75°C column) and Table 310.15(B)(3)(a) Adjustment Factors

Answer: 52 amps

5. Problem: What is the ampacity of (8) 8 AWG XHHW Aluminum current-carrying conductors installed in E.M.T. located in a dry location, in an ambient temperature of 60°C?

Solution: 45 amps × .71 × 70% = 22.365 amps - Table 310.15(B)(16) (90°C column), Ambient Temperature Correction Factors from Table 310.15(B)(2)(a) Adjustment Factors

Answer: 22 amps

6. Problem: Six 14 AWG THW current-carrying copper conductors are installed in E.M.T. located in a boiler room having an ambient temperature of 55°C. What is the maximum allowable load current for each conductor?

Solution: 20 amps × .67 × 80% = 10.72 amps
Table 310.15(B)(16) (75°C column), Ambient Temperature Correction Factor from Table 310.15(B)(2)(a) and Table 310.15(B)(3)(a)

Answer: 11 amps

7. Problem: What is the ampacity of (15) 10 AWG THHN copper current-carrying conductors installed in Rigid Metal Conduit?

Solution: 40 amps × 50% = 20 amps
Table 310.15(B)(16) (90°C column) and Table 310.15(B)(3)(a) Adjustment Factors

Answer: 20 amps

8. Problem: What is the maximum allowable ampacity for 6 AWG THHN copper conductors terminated in 60°C lugs?

Solution: Table 310.15(B)(16) (60°C Column), 110.14(C)

Answer: 55 amps

9. Problem: What is the maximum allowable ampacity for (8) 4 AWG THHN copper current-carrying conductors installed in E.M.T. in an ambient temperature of 105°F and terminated in 60°C lugs?

Solution:

a) 95 amps × .87 × 70% = 57.855 amps - Table 310.15(B)(16) (90°C column), Ambient Temperature Correction Factor from Table 310.15(B)(2)(a) and Table 310.15(B)(3)(a) Adjustment Factors

b) 4 AWG THHN copper, 60°C column = 70 amps - Table 310.15(B)(16), 110.14(C)

c) The lowest ampacity between derating the 90°C column or the 60°C column without derating is the 90°C column with derating, or 58 amps. 310.15(A)(2)

Answer: 58 amps

10. Problem: What is the maximum allowable ampacity for (3) 3 AWG THHN copper current-carrying conductors installed in E.M.T. in an ambient temperature of 35°C and terminated in 60°C lugs?

Solution:

a) 115 amps × .96 = 110.4 amps - Table 310.15(B)(16) (90°C column), and Ambient Temperature Correction Factor from Table 310.15(B)(2)(a)

b) 3 AWG THHN copper, 60°C column = 85 amps - Table 310.15(B)(16), 110.14(C)

c) The lowest ampacity between derating the 90°C column or the 60°C column without derating is the 60°C column without derating, or 85 amps. 310.15(A)(2)

Answer: 85 amps

11. Problem: What is the ampacity of (4) 12-2/G NMB cables bundled together longer than 24 inches?

Solution:

a) 30 amps $\times$ 70% = 21 amps
Table 310.15(B)(16) 90°C Column and Table 310.15 (B)(3)(a) Adjustment Factors, 334.80

b) 12 AWG, 60°C Column = 20 amps
Table 310.15(B)(16), 334.80

c) The lowest ampacity between derating the 90°C column or the 60°C column without derating is the 60°C column without derating or 20 amps.

Answer: 20 amps (Note: The overcurrent protection for 12 AWG shall generally not exceed 20 amperes—240.4(D))

12. Problem: What size THW copper conductors installed in E.M.T. would be required for a 40-amp load in an ambient temperature of 45°C and terminated in 75°C lugs?

Solution:

40 amps $\div$ .82 = 48.8 amps
Table 310.15(B)(16) Ambient Temperature Correction Factor from Table 310.15(B)(2)(a)
49 amps = 8 AWG THW copper
Table 310.15(B)(16) (75°C column), 110.14(C)

Answer: 8 AWG THW copper

13. Problem: What size THW copper conductors would be required for a 50-amp, 240-volt, single-phase load with no neutral conductor installed in E.M.T. in an ambient temperature of 120°F installed in the same conduit with (6) 10 AWG THW copper conductors and terminated in 75°C lugs?

Solution:

50 amps $\div$ .75 $\div$ .70 = 95.2 amps
Table 310.15(B)(16) Ambient Temperature Correction Factor from Table 310.15(2)(a) and Table 310.15(B)(3)(a) Adjustment Factors
95 amps = 3 AWG THW copper
Table 310.15(B)(16) (75°C column), 110.14(C)

Answer: 3 AWG THW copper

14. Problem: What size THW copper conductors installed in EMT are required for a single-phase, 60-amp load which has terminals rated for 60°C?

Solution: Table 310.15(B)(16) (60°C Column)
110.14(C)

Answer: 4 AWG THW copper

15. Problem: What size THHN copper conductors, terminated on 75ºC lugs, are required for a 150 amp single family dwelling service?

Solution:	150 amps x .83 = 124.5 amps	310.15(B)(7)(1)
	125 amps = 1 AWG THHN copper	Table 310.15(B)(16)

Answer: 1 AWG THHN copper

16. Problem: What size THW aluminum conductors, terminated on 75ºC lugs, are required for a 200 amp single family dwelling service installed in an ambient temperature of 105ºF?

Solution:	200 amps x .83 = 166 amps	310.15(B)(7)(1)
	166 amps ÷ .82 = 202.4 amps	310.15(B)(7) Informational Note No. 1
	202 amps = 250 kcmil THW Aluminum	Table 310.15(B)(16) 75ºC Colum

Answer: 250 Kcmil THW Aluminum

17. Problem: What is the maximum size service rating allowed for a dwelling unit supplied by 2/0 AWG THW copper conductors terminated in 75°C lugs?

Solution:	2/0 AWG THW copper = 175 amps	Table 310.15(B)(16) 75ºC Column
	175 amps ÷ .83 = 210.8 amps	310.15(B)(7)(1)

Answer: Next lower standard rating = 200 amps 240.6

18. Problem: What size THW aluminum conductors terminated in 75°C lugs are required for a single-family dwelling with a 400-amp, 120/240-volt, single-phase service?

Solution:	400 amps x .83 = 332 amps	310.15(B)(7)(1)
	332 amps = 600 kcmil THW Aluminum	Table 310.15(B)(16) 75°C column

Answer: 600 kcmil THW Aluminum

19. Problem: What is the ampacity of 6 AWG Type SO cord with 2 current-carrying conductors?

Solution: Table 400.5(A)(1) Column B

Answer: 55 amps

20. Problem: What is the ampacity of 10 AWG Type SJ cord with 8 current-carrying conductors?

Solution: 10 AWG SJ cord = 25 amps — Table 400.5(A)(1) Column A
25 amps × 70% = 17.5 amps — 400.5, Table 400.5(A)(3)

Answer: 18 amps

21. Problem: What is the ampacity of 2 AWG Type W portable power cable with 3 current-carrying conductors rated for 75°C?

Solution: 2 AWG Type W portable power cable = 133 amps
Table 400.5(A)(2) 75°C Column Subheading F

Answer: 133 amps

22. Problem: What size THW copper branch circuit conductors are required for a 29-amp continuous load terminated on 75°C lugs?

Solution: 29 amps × 125% = 36.25 amps — 210.19(A)(1)
36 amps = 8 AWG THW copper — Table 310.15(B)(16) (75°C column), 110.14(C)

Answer: 8 AWG THW copper

23. Problem: What is the ampacity of (8)12-2/G MC cables with THHN copper conductors, bundled together and supported on "bridle rings"?

Solution: Table 310.15(B)(16) 90°C Column = 30 amps — 310.15 (B)(3)(a)(4)

Answer: 30 amps

24. Problem: What is the ampacity of (24)12-2/G MC cables with THHN copper conductors, bundled together and supported on "bridle rings"?

Solution: 30 amps × 60% = 18 amps
Table 310.15(B)(16) 90°C Column, 310.15(B)(3)(a)(4) Ex.

Answer: 18 amps

25. Problem: What is the ampacity of a 4/0 THHN copper conductor in free air in an ambient temperature of 110°F?

Solution: 4/0 AWG THHN copper = 405 amps
405 amps × .87 = 352.4 amps
Table 310.15(B)(17) 90°C Column and Ambient Temperature Correction Factor from Table 310.15(B)(2)(a)

Answer: 352 amps

26. Problem: What is the ampacity of a 250 kcmil XHHW-2 aluminum triplex?

Solution: 250 kcmil XHHW-2 aluminum triplex = 292 amps
Table 310.15(B)(20)

Answer: 292 amps

27. Problem: What is the ampacity of (6) 4 AWG THHN copper current-carrying conductors installed in E.M.T. that have a total length of 150 feet but of which 20 feet pass through a boiler room with an ambient temperature of 125°F?

Solution: 95 amps × .76 × 80% = 57.8 amps
Table 310.15(B)(16) 90°C Column, Ambient Temperature
Correction Factors from Table 310.15(B)(2)(a), Table 310.15 (B)(3)(a)
Adjustment Factors, 310.15 (A)(2) Ex.

Answer: 58 amps

Note: Another way of stating 310.15(A)(2) Exception is:
If 10 feet or 10 percent of the circuit length or more is located in a higher ambient temperature than the remainder of the circuit, the entire circuit must be calculated at the higher ambient temperature.

28. **Problem:** What is the ampacity of (4) 8 AWG THHN copper current-carrying conductors installed in E.M.T. and exposed to direct sunlight in an ambient temperature of 100°F and run horizontally ½ inch above a roof?

Solution:
a) 8 AWG THHN copper = 55 amps
Table 310.15(B)(16) 90°C Column
b) ½ Inch = 60ºF
100°F + 60°F = 160°F
160°F = .50 Table 310.15(B)(2)(a) 90°C Column Correction Factors
c) 4 Conductors = 80% Table 310.15(B)(3)(a)
d) 55 amps x .50 x 80% = 22 amps

Answer: 22 amps