

# Conductor Ampacity and Derating

## A. UNDERSTANDING CONDUCTOR AMPACITY

### Comparison of Water and Electrical Flow

	<u>Water</u>	<u>Electrical</u>
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  $6.28 \times 10^{18}$  or 6,280,000,000,000,000 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-amperes 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 coordinates 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. If circular raceways are exposed to direct sunlight or rooftops, include temperature adder from Table 310.15(B)(3)(c).

**Temperatures Inside Conduits on Rooftops Exposed to Direct Sunlight**

Colorado City	2% Design				Maximum Temperature	
	Temp	Distance above Roof				
		0 - 1/2"	1/2" - 3 1/2"	3 1/2" - 12"		12" - 36"
Alamosa	84	144	124	114	109	106
Aurora	91	151	131	121	116	104
Colorado Springs	89	149	129	119	114	99
Craig	88	148	128	118	113	100
Denver	93	153	133	123	118	105
Eagle	87	147	127	117	112	98
Fort Collins	91	151	131	121	116	104
Grand Junction	96	156	136	126	121	106
La Junta	99	159	139	129	124	112
Limon	90	150	130	120	115	99
Pueblo	97	157	137	127	122	106
Trinidad	92	152	132	122	117	103

- 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 three 1/0 THHN copper 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 three 250 kcmil XHHW aluminum 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 three 12 AWG THHN copper conductors installed in E.M.T. in an ambient temperature of 120°F?

Solution:  $30 \text{ amps} \times .82 = 24.6 \text{ amps}$  - 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 conductors installed in Rigid Metal Conduit?

Solution:  $65 \text{ amps} \times 80\% = 52 \text{ amps}$  - 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 conductors installed in E.M.T. located in a dry location, in an ambient temperature of 60°C?

Solution:  $45 \text{ amps} \times .71 \times 70\% = 22.365 \text{ amps}$  - 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:**  $20 \text{ amps} \times .67 \times 80\% = 10.72 \text{ amps}$   
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 conductors installed in Rigid Metal Conduit?

**Solution:**  $40 \text{ amps} \times 50\% = 20 \text{ amps}$   
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 conductors installed in E.M.T. in an ambient temperature of 105°F and terminated in 60°C lugs?

**Solution:**

- a)  $95 \text{ amps} \times .87 \times 70\% = 57.855 \text{ amps}$  - 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 conductors installed in E.M.T. in an ambient temperature of 35°C and terminated in 60°C lugs?

**Solution:**

- a)  $115 \text{ amps} \times .96 = 110.4 \text{ amps}$  - 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)  $30 \text{ amps} \times 70\% = 21 \text{ amps}$   
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:**

$40 \text{ amps} \div .82 = 48.8 \text{ amps}$   
Table 310.15(B)(16) Ambient Temperature Correction Factor from Table 310.15(B)(2)(a)  
 $49 \text{ amps} = 8 \text{ AWG THW copper}$   
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:  $50 \text{ amps} \div .75 \div .70 = 95.2 \text{ amps}$   
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 are required for a 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 is the maximum allowable ampacity for 2/0 THW copper conductors terminated in 75°C lugs and used for a 120/240-volt, single-phase dwelling service?

Solution: Table 310.15(B)(7)

Answer: 200 amps

- 16. 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: Table 310.15(B)(7)

Answer: 600 kcmil THW Aluminum

- 17. 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

- 18. 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

$25 \text{ amps} \times 70\% = 17.5 \text{ amps}$   
400.5, Table 400.5(A)(3)

Answer: 18 amps

- 19. 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

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

Solution:  $29 \text{ amps} \times 125\% = 36.25 \text{ amps}$  210.19(A)(1)  
 $36 \text{ amps} = 8 \text{ AWG THW copper}$  Table 310.15(B)(16) (75°C column),  
110.14(C)

Answer: 8 AWG THW copper

- 21. 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

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

Solution:  $30 \text{ amps} \times 60\% = 18 \text{ amps}$   
Table 310.15(B)(16) 90°C Column, 310.15(B)(3)(a)(5)

Answer: 18 amps

- 23. 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 THHN Copper = 405 amps  
 $405 \text{ amps} \times .87 = 352.4 \text{ amps}$   
Table 310.15(B)(17) 90°C Column and Ambient Temperature Correction Factor  
from Table 310.15(B)(2)(a)

Answer: 352 amps

- 24. 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
- 25. Problem:** What is the ampacity of (6) 4 AWG THHN copper 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:**  $95 \text{ amps} \times .76 \times 80\% = 57.8 \text{ amps}$   
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:** 310.15 (A)(2) Ex. States that 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.
- 26. Problem:** What is the ampacity (4) 8 AWG THHN copper conductors installed in E.M.T. and exposed to direct sunlight in an ambient temperature of 100°F and located 3 inches above a roof?
- Solution:** a) 8 AWG THHN copper = 55amps  
Table 310.15(B)(16) 90°C Column  
b) 3 inches = 40°F Table 310.15(B)(3)(C)  
 $100^\circ\text{F} + 40^\circ\text{F} = 140^\circ\text{F}$   
 $140^\circ\text{F} = .71$  Table 310.15(B)(2)(a) 90°C Column  
Correction Factors  
c) 4 Conductors = 80% Table 310.15(B)(2)(a)  
d)  $55 \text{ amps} \times .71 \times 80\% = 31.24 \text{ amps}$
- Answer:** 31 amps