UNIT

6

CONDUCTOR SIZING AND PROTECTION CALCULATIONS

Introduction to Unit 6—Conductor Sizing and Protection Calculations

Every conductor has a certain amount of resistance. Any time current flows through a conductor there's resistance, and heat is generated. The amount of heat produced is directly proportional to the resistance of the wire and the square of the current flow. In order to determine what size conductor is needed to carry a certain amount of current, the heat that will be generated must be taken into consideration. The number of conductors in the same raceway that are carrying current can affect this decision, as can the ambient or surrounding temperature. This unit explains how to evaluate these factors and make the proper choice when sizing electrical conductors, and how to select the proper conductor based on the temperature rating of the equipment terminals. This can become a complicated choice, and you should study this unit carefully to learn how to make the right conductor sizing decisions.

The amount of current you allow a conductor to carry must be limited to a level that won't cause it to overheat. Knowing how to correctly size and protect conductors eliminates the possibility of overheating under normal operating conditions and prevents possible damage to the conductor insulation, equipment terminations, and (more importantly) any combustible building structure the conductor may encounter. In order to make sure the amount of current in a conductor is kept within safe limits, overcurrent protection is used to open the circuit if necessary. This protection is generally provided by installing a fuse or circuit breaker, of a size based on the conductor's ampacity, at the point where the conductor receives its supply. The general rules for overcurrent protection are covered in this unit, along with exceptions to these requirements; for example, those for tap conductors and special cases such as motor circuits. Some specific overcurrent applications and tap rules will be discussed to help you become familiar with the rules for sizing overcurrent protective devices in this unit. Motor, air-conditioning and transformer circuits will be covered in more depth in Unit 7.

6.1 Conductor Insulation [310.4]

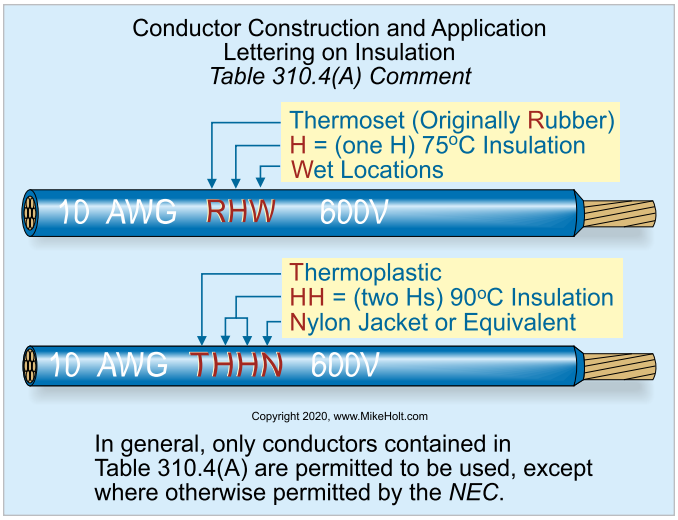
Scan this QR code for a video of Mike explaining this topic; it's a sample from the videos that accompany this textbook.
www.MikeHolt.com/20CALCvideos

Table 310.4(A) provides information on conductor insulation properties such as letter type, maximum operating temperature, application, insulation, and outer cover properties. Only conductors in Table 310.4(A) can be installed for the application identified in the table.

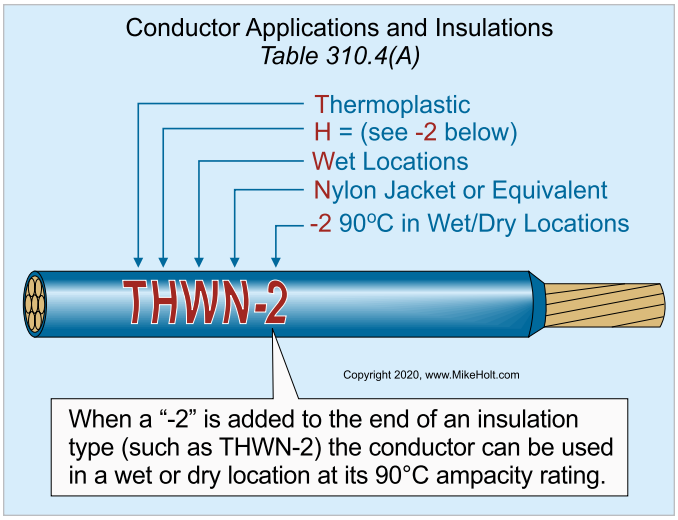
In general, only those conductors contained in Table 310.4(A) can be used, except where otherwise permitted in the *NEC*. Some examples are PV wire, PV cables, or DG cable [690.31(C)].

Author's Comment:

- The following explains the lettering on conductor insulation [Table 310.4(A)]: ▸Figure 6–1
  - No H 60°C insulation rating
  - H 75°C insulation rating
  - HH 90°C insulation rating permitted in dry locations
  - -2 90°C insulation rating permitted in wet locations
  - N Nylon outer cover
  - T Thermoplastic insulation
  - U Underground
  - W Permitted in wet or damp locations



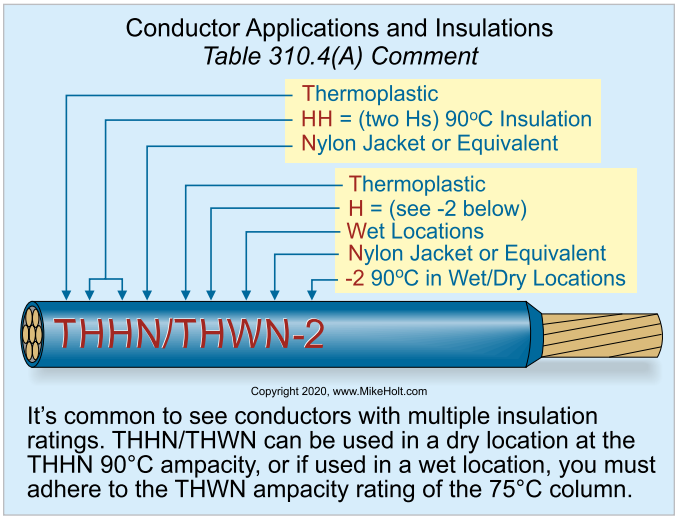
▸Figure 6–1



▸Figure 6–3

Author's Comment:

- It's common to see conductors with a multiple insulation rating, such as THHN/THWN. This type of conductor can be used in a dry location at the THHN 90°C ampacity. If it's used in a wet location, you must adhere to the THWN ampacity rating of the 75°C column of Table 310.16 for THWN insulation types. ▸Figure 6–2
- When a "-2" is added at the end of an insulation type (such as THWN-2), that means the conductor can be used in a wet or dry location at the 90°C ampacity rating. ▸Figure 6–3

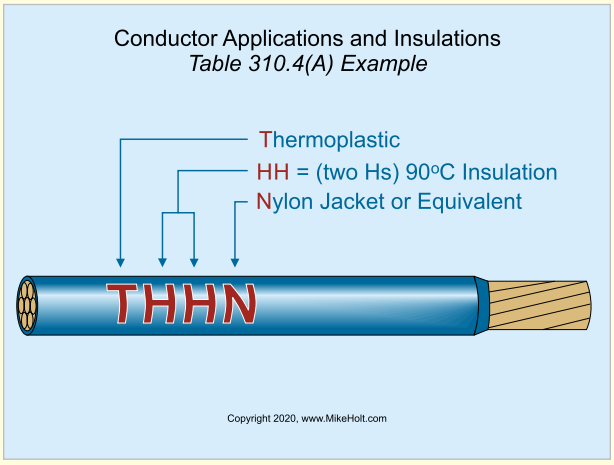


▸Figure 6–2

▶ Table 310.4(A) Conductor Insulation Example

Question: *Which of the following describe(s) Type THHN insulation?* ▸Figure 6–4

(a) Thermoplastic insulation.
(b) Suitable for dry or damp locations.
(c) A maximum operating temperature of 90°C.
(d) all of these



▸Figure 6–4

Answer: *(d) all of these*

Other Conductor Construction and Application

For more information about fixture wires, see Article 402, Table 402.3, and Table 402.5. For more information on flexible cords and flexible cables, see Article 400, Table 400.4, Table 400.5(A), and Table 400.5(B).

Table 310.4(A) Conductor Applications and Insulations					
	Column 2	Column 3	Column 4	Column 5	Column 6
Type Letter	Insulation	Max. Operating Temperature	Application	Sizes Available AWG or kcmil	Outer Covering
RHH	Flame-retardant thermoset	90°C	Dry and damp locations	14 – 2,000	Moisture-resistant, flame-retardant, nonmetallic
RHW	Flame-retardant, moisture-resistant thermoset	75°C	Dry and wet locations	14 – 2,000	Moisture-resistant, flame-retardant, nonmetallic
RHW-2	Flame-retardant, moisture-resistant thermoset	90°C	Dry and wet locations	14 – 2,000	Moisture-resistant, flame-retardant, nonmetallic
THHN	Flame-retardant, heat-resistant thermoplastic	90°C	Dry and damp locations	14 – 1,000	Nylon jacket or equivalent
THHW	Flame-retardant, moisture- and heat-resistant thermoplastic	75°C 90°C	Wet locations Dry locations	14 – 1,000	None
THW	Flame-retardant, moisture- and heat-resistant thermoplastic	75°C	Dry, damp, and wet locations	14 – 2,000	None
THW-2	Flame-retardant, moisture- and heat-resistant thermoplastic	90°C	Dry, damp, and wet locations	14 – 1,000	None
THWN	Flame-retardant, moisture- and heat-resistant thermoplastic	75°C	Dry, damp, and wet locations	14 – 1,000	Nylon jacket or equivalent
THWN-2	Flame-retardant, moisture- and heat-resistant thermoplastic	90°C	Dry, damp, and wet locations	14 – 1,000	Nylon jacket or equivalent
TW	Flame-retardant, moisture-resistant thermoplastic	60°C	Dry, damp, and wet locations	14 – 2,000	None
USE	Heat- and moisture-resistant	75°C	See Article 338	14 – 2,000	Moisture-resistant nonmetallic
USE-2	Heat- and moisture-resistant	90°C	See Article 338	14 – 2,000	Moisture-resistant nonmetallic

▶ Table 400.4 Flexible Cord Example

Question: *SJO can be described as _____.*

(a) oil-resistant thermoset outer covering
(b) usable in damp locations
(c) 300V insulation
(d) all of these

Answer: *(d) all of these*

▶ Table 402.3 Fixture Wire Example

Question: *Which of the following describe(s) Type TFFN insulation?*

(a) Flexible stranded fixture wire.
(b) Thermoplastic insulation with a nylon outer cover.
(c) Suitable for dry and wet locations.
(d) a and b

Answer: *(d) a and b*