

COPPER VS. ALUMINUM CONDUCTORS

Conductors consist of materials that conduct electric current, or the flow of electrons. Nonmagnetic metals are typically considered to be ideal conductors of electricity. The wire and cable industry uses a variety of metal conductors, but the two most common are copper and aluminum. Conductors have different properties such as conductivity, tensile strength, weight and environmental exposure.

COPPER CONDUCTORS

Copper is one of the oldest known materials. Its ductility and electrical conductivity were exploited by the early experimenters with electricity, such as Ben Franklin and Michael Faraday. Copper was the conductor used in inventions such as the telegraph, telephone and electric motor.

With the exception of silver, copper is the most common conductive metal and has become the international standard. The International Annealed Copper Standard (IACS) was adopted in 1913 to compare the conductivity of other metals to copper. According to this standard, commercially pure annealed copper has a conductivity of 100 percent IACS. Commercially pure copper produced today may have higher IACS conductivity values as processing technology has improved over time.

In addition to copper's superior conductivity, the metal contains great tensile-strength, thermal-conductivity and thermal-expansion properties. Annealed copper wire used for electrical purposes meets the requirements of ASTM B3, Specification for Soft or Annealed Copper Wire.

ALUMINUM CONDUCTORS

Even though copper has a long history as the material of choice for conducting electricity, aluminum has certain advantages that make it attractive for specific applications.

Aluminum has 61 percent of the conductivity of copper, but has only 30 percent of the weight of copper. That means that a bare wire of aluminum weighs half as much as a bare wire of copper that has the same electrical resistance. Aluminum is generally more inexpensive when compared to copper conductors.

Aluminum conductors consist of different alloys known as the AA-1350 series and AA-8000 series. AA-1350 has a minimum aluminum content of 99.5 percent. In the 1960s and 1970s, due to the high price of copper relative to aluminum, this grade of aluminum began to be popularly used for household wiring. Due to low-quality workmanship at connections and the physical differences between aluminum and copper, high-resistance connections formed and became a fire hazard.

As a response, aluminum alloys were developed to have creep and elongation properties more similar to copper. These AA-8000 series alloys are the only solid or stranded aluminum conductors permitted to be used according to Article 310 of the 2014 National Electric Code*. AA-8000 series alloys meet the requirements of ASTM B800, Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes—Annealed and Intermediate Tempers.

COMPARISON

If aluminum is used in an application where copper was previously used, it is typically sufficient to use an aluminum conductor two AWG sizes larger than that of copper. A comparison between aluminum and copper for the same application is listed below.

Comparison of XHHW-2 properties	AA-8000 series aluminum	Copper
AWG size for 60 A at 75°C	6	8
Weight per 1,000 ft.	39 lb.	65 lb.
Nominal diameter	0.26 in.	0.23 in.
Maximum pulling tension	157 lb.	132 lb.

APPLICATIONS

Copper is much more commonly used for building wire than aluminum. Nearly all electronic cables are made from copper, as are other products that take advantage of the high conductivity of copper. Copper conductors are also commonly used in power distribution, power generation and automotive applications.

For the weight and cost savings, electrical utilities use aluminum for overhead transmission lines. Aluminum also sees usage where its low-weight properties are important, such as aircraft and future applications in automobiles. For large coaxial cables, copper-clad aluminum wire can be used to take advantage of the conductivity of copper while gaining the weight savings of aluminum.

CONNECTORS

Connectors must be rated for use with aluminum. Connections rated for use with aluminum are frequently also able to be used with copper and are marked as so, such as AL7CU, a connector suitable for use with copper or aluminum conductors at 75°C. In applications where connections need to be soldered, copper or tinned copper is preferred, as aluminum is difficult to solder.

*2014 NEC 310.106(B)

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