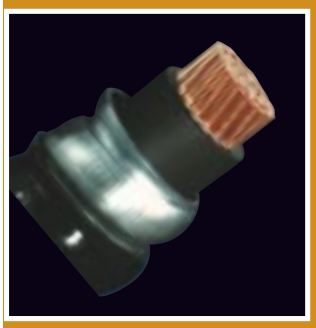


The colour of trust.

A comparison of copper versus aluminum electrical wire and cable

Copper has earned its position as the most efficient and reliable electrical conductor for commercial and industrial wire and cable over decades of reliable service.

Copper wins the conductivity contest

Copper has the highest electrical conductivity of all engineering metals. This means that a copper cable is smaller than an equivalent ampacity aluminum cable.[1] Smaller cables mean an easier and less costly installation.

Copper is strong and tough

Compared to aluminum alloy, the harder and stronger copper conductors are more resistant to the inevitable nicks and mechanical abuse to which a cable is subjected during installation. This is a real advantage at junction and termination boxes where copper conductors can be bent further, twisted tighter and pulled harder without stretching and breaking. Conversely, aluminum is softer, has a lower modulus of elasticity than copper and cold flows away from a stressed area when connected under high pressure.[1]

Copper connections have a proven track record

Copper is a very forgiving metal to join electrically and has been throughout its history of use. Contrary to the experience with aluminum, copper connections have never been the weak link in a wire or cable system.[2]

Aluminum connections can be inconsistent because of:[3]

- The critical installation procedures required to assure a good connection.
- An ever-present insulating oxide.
- A thermal expansion coefficient much larger than that of copper.
- The real threat of corrosion.

Many connections of aluminum alloy conductors have been tested to the ANSI C119.4 500-cycle test, sometimes modified by a Current Cycle Submersion Test (CCST) of 100 cycles. (At least 1600 cycles should be used to approximate real life conditions.) Field experience has shown that too many of the connections tested to these standards easily pass the requirements yet fail when exposed to real operating conditions in the field. This happens because the performance criteria of the tests are not based on the new theories of electrical contacts and their degradation.[4]

The debate stops here. Properly made copper connections run cooler than their aluminum equivalent, ensuring that copper connections will have a longer life.

Copper has an ampacity advantage

The ampacities for a large range of wire and cable sizes and installation conditions have been precisely established by the Insulated Conductors Committee of the IEEE and published in IEEE Standard 835-1994. This standard is used throughout the world by engineers, planners and system designers. The tables in the standard show that the ampacity of copper conductors is approximately 1.6 times that of aluminum alloy conductors of the same size, because of copper's inherent higher conductivity.[5]

Copper is easier to install

Since a copper cable can have a smaller diameter and less stiff insulation, armour and jacketing than an aluminum cable, it is more flexible and requires less effort to bend into position during installation.[6]

Transport of the less-bulky copper cable to the installation site is often easier since it requires a smaller reel. In addition, the smaller copper cable permits installation in locations where space is limited and at a premium.

Copper is corrosion resistant

Aluminum alloys are more active metals than copper and in the presence of moisture (water) will corrode. This susceptibility to corrosion shortens the life of a cable.[7]

Water can gain entrance into a cable during shipping, handling, outside storage, accidental damage or cable joint or termination failures.

Water in a copper cable will not cause serious corrosion. But, the water in contact with the aluminum conductor of an insulated wire or cable will result in severe corrosion with the conversion of aluminum to a hydroxide and hydrogen gas. Hydroxide has a larger volume than the metal, and its formation will lead to a damaging expansion of the cable insulation structure and eventual destruction of the cable. The hydrogen gas produced can often reach high pressures with damaging results.[8, 9]

The insidious nature of corrosion is illustrated by an example of one utility's experience where an aluminum alloy conductor was contaminated from handling with sweaty hands and then terminated under binding posts. Under humid conditions but without voltage applied, 70% of the conductors and/or connections were so corroded in two days that they were no longer serviceable.[10, 11]

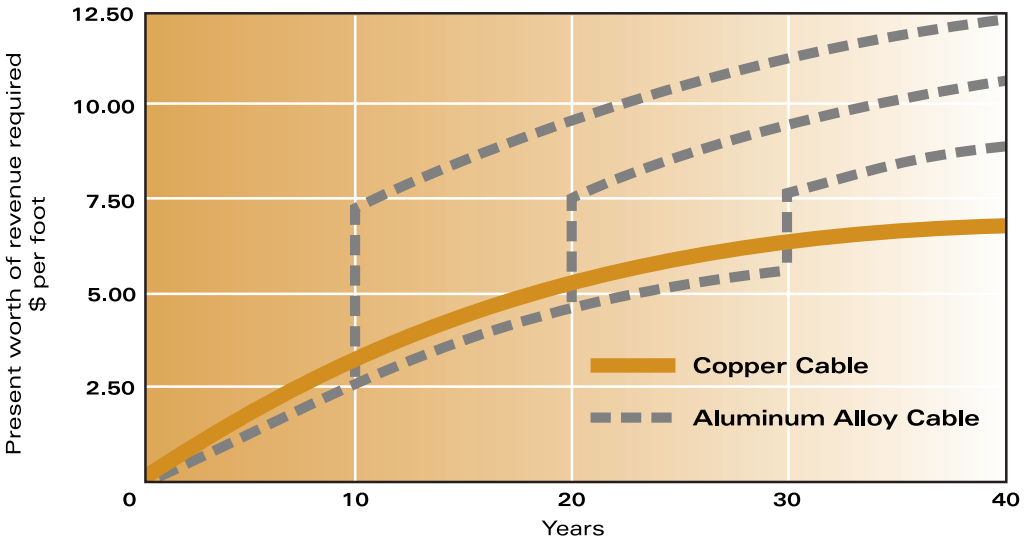
Aluminum conductors require special protection and can not be used as equivalents or replacements for copper in certain critical applications. For example, the Canadian Electrical Code only allows copper conductors to be used for fire alarm and fire pump circuits.[12]

Failed aluminum cable from water corrosion

The full life cycle cost of a copper cable is lower

An economic comparison between copper and aluminum alloy cables is important to the buying decision. On a first-look basis, an aluminum cable is sometimes cheaper than a copper cable. But real economy should not be measured by first cost alone. That's why the life cycle cost, which includes cable life and the cost of installation, materials, maintenance, repairs and possible replacement must also be considered, together with the potential liability of poor service performance.

Analyses of the parameters involved have proven that the key variable is "life". The longest life alternative has the lowest total cost and provides the greatest value. But there is a risk in projecting the life of an aluminum alloy cable. Only a copper cable eliminates the risk of projecting cable life because, unlike aluminum, the life of copper is based on actual field performance, not merely short-term accelerated laboratory tests.[13] The curves on the following chart show that early failure of aluminum alloy cable is extremely costly. The examples are of failures at 10, 20 and 30 years.



The colour of trust

Commercial and industrial power cables are long-term assets critical to the financial health of your investment and their performance directly affects your profitability. Copper's unparalleled reliability started over a century ago, and it continues today. Copper is the colour of trust for commercial and industrial power cables.

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1) Northern Electric Company Limited,"Electrical Conductors Handbook", 1978.
2) L. Lamarre and C. Dang, "Characterization of Medium Voltage Cable Splices Aged in Service". Proceedings of the JICABLE 1991 International Conference, Versailles, France, June 1991.
3) IEEE Insulated Conductors Committee Minutes, November, 1973, Project 10-37, "Guide For Connecting Insulated Aluminum Conductors".
4) M. Braunovic, "Aluminum Connections : Legacies of the Past", November/December 1992 Electrical Equipment News.
5) IEEE Standard Power Cable Ampacity Tables, Std. 835-1994.
6) S. Timashenko, G.H. MacCullough, "Elements of Strength of Materials", D. Van Nostrand Co. Inc.
7) R. Elford, "Design Considerations for Covered Conductor Distribution", Distribution 2000, Melbourne, Australia, November 1993.
8) G.J. Luzzi, "Gas Pressure Build-Up in Aluminum Conductor Cable", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-101, No. 6, June 1982.
9) J.H. Lawson, A. Kong, "Self-Sealing Direct-Buried 600 Volt Secondary Cable", IEEE Transactions on Power Delivery, Vol. 4, No. 1, January 1989.
10) D.C. Alexander, R. Tatman, "Paper Insulated Telephone Cables", Proceedings 19th International Wire & Cable Symposium, 1971.
11) "Aluminum as an Alternative to Copper in the Bell Canada Outside Plant Network", March 1974.
12) Canadian Electrical Code, Rules 32-100 and 32-200.
13) TAG - Technical Assessment Guide, Electric Power Research Institute P-4463-SR, Volume 3 Special Report, May 1987.

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