Cable Lore

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COPPER OR ALUMINUM IN WIRE AND CABLE

INTRODUCTION

All metals by definition conduct current, some better than others. Silver, copper and aluminum are the most efficient widely available metals. Silver, the most conducting of the three, is too costly except for special applications. Copper is more conducting but more expensive than the several aluminum alloys used commercially for electrical conductors. The choice of copper or aluminum in wire and cable should depend upon the application and the parameters involved in that application. When reliability, small size or ease of installation are paramount, copper should be used. When low initial cost or light weight are paramount, aluminum should be used, but not merely as a substitute for copper conductors across the broad spectrum of power and control cable applications. For any application, the cable should be designed around the unique characteristics of the conductor metal selected.

PRESENT STATUS OF ALUMINUM IN WIRE AND CABLES

1. High voltage overhead transmission cables and supporting equipment. A complete redesign of the original copper product has resulted in satisfactory aluminum systems. Steel wire or high strength aluminum alloy reinforcement assisted in providing the necessary strength to make this a reliable and technically sound application. The light weight resulted in lower cost structures. The larger diameter for the same electrical conductance reduced corona and radio noise.

2. Medium voltage cables with extruded insulations. The original design with copper conductors and conductive fibrous tapes over the conductor has an excellent record of reliability. Direct substitution of aluminum for copper as the conductor in this cable concept led to conductor corrosion and cable failure when moisture was present with a limited supply of oxygen. The combination of free carbon and water in fibrous tapes with an aluminum conductor was conducive to galvanic action. A redesign of the product to require non-fibrous extruded conductive layers over the aluminum has essentially eliminated the problem.

3. Type URD cable. While aluminum has replaced copper in the center conductor, the concentric conductor usually remains copper, even though a few experimental installations of URD with aluminum concentric wires are working well in special soil conditions, when protected properly by cathodic over-voltages. Further, if the evidence of corrosion of copper neutrals becomes sufficiently persuasive, the new standard design may well use aluminum concentric wires with a protective conductive jacket overall.

4. High voltage pipe cables. Now that the inert gas welding technique for aluminum conductors has proven its reliability, the choice between aluminum and copper is basically one of economics. The economics, of course, are complicated by the interactions between cable diameter and required size of pipe and between cable weight and manhole

spacing. At the higher voltages, the greater thermal expansion of aluminum vs copper may adversely affect cable life, because thicker insulation walls seem more susceptible to take displacement.

5. Building Wire. When a cable is redesigned around aluminum instead of copper, connectors and termination methods must all be redesigned. While satisfactory reliability results have been achieved for the four preceding applications, much controversey still exists concerning the safety of using small size aluminum conductors in building wire applications. The state of the art has not reached a plateau of "off the shelf" such that a high level of reliability can be routinely achieved by an electrical journeyman. This position is supported by the various fact-finding investigations by UL on the receptacles for the various aluminum alloys. Metallurgists and accessory manufacturers are still trying to develop alloys and connectors to increase termination reliability. For the present, the extra care and skill required to terminate aluminum compared with copper reduces the savings from the lower metal cost of aluminum versus copper.

HOW ABOUT THE FUTURE?

Copper has a historical advantage over aluminum in that it was available at the birth of the power cable industry. Manufacturing equipment, processing, evaluation and application have developed on the basis of experience with copper. The same is true for supporting technology, such as connectors and other terminating equipment. Data in each one of these areas became standards or reference points and some requirements have not changed significantly in over thirty years. In other words, it is generally agreed that copper is the standard for technical comparison.

On the other hand, aluminum has been the standard for economic comparison. Copper, historically, has had a pattern of widely fluctuating prices due to the impact of a wide fluctuation in demand on a relatively limited supply. Aluminum has been in plentiful supply at low, stable prices. According to Wire Technology[1], in 1973 aluminum increased its market share almost 30% over its share in 1972, the largest increase since 1967. On a straight weight basis, aluminum had 17.7% of the conductor market, but when allowance is made for the fact that one pound of aluminum replaces approximately two pounds of copper, aluminum had 26.1% of the conductance market.

The economic situation, of course, has recently changed because the increased costs of electric power weigh more heavily on the production of aluminum than of copper. Furthermore, the costs of bauxite, the least expensive raw material for aluminum, are increasing partly by governmental actions of the nations controlling this resource. In 1973, copper cost 2.36 times that of aluminum, a very high ratio compared to the 1.36 ratio in 1964. Currently, the ratio is 1.76. In other words, the economic incentives toward the use of aluminum are lessening for the moment.

Such a change in the econmics is not going to influence the choice of copper or aluminum in many applications. The lighter weight of aluminum per unit of conductivity is a major factor in making aluminum the preferred metal for overhead transmission cable. On the other hand, copper is frequently chosen in spite of its higher cost because of its smaller volume per unit conductivity, which is particularly important in electrical component uses. Copper is also the material of choice in cases where vibrational stress or environmental considerations due to metallurgical reactions arising from the joint of aluminum to existing brass hardware are im-

1. Weighing the Merits of Copper vs Aluminum - Wire Technology March/April 1975 p 9-15

portant factors. Finally, the conductivity, durability, and anti-corrosion properties of copper are superior to those of aluminum and usually lead to copper's selection for application in which these parameters are important.

Contractors prefer to work with copper because there are fewer problems There are no problems with lugs or connectors. Copper handles better and bends more easily. It pulls easier and is more flexible. Copper does not nick as easily and does not break as easily when nicked, compared with aluminum. Special copper-aluminum fittings are not required and less care is required in tightening connections. Copper is easier to handle when rewiring is involved. If a conduit is already crowded, small gauge copper wire has an edge over aluminum.

It should still be recognized that economics still favor aluminum and will until aluminum costs twice as much per pound as copper. This is a powerful factor in encouraging attempts to design reliable cables around aluminum in place of copper for applications in which copper is now the metal of choice. Further replacements will depend upon innovating design and data from sound test programs confirming the safety and relability of the new design.

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