White Paper

Aluminum Cable for Wireless Antenna Feeder Applications

Introduction

With the continuing rise in copper prices over recent months, the cost of copper cables has correspondingly increased. Users of such cables for wireless infrastructure are looking for more cost-effective products.

Andrew Corporation has recently introduced a new type of feeder cable for wireless infrastructure applications. Based on established foam-dielectric cable designs that Andrew has been supplying for many years, this new cable type uses a corrugated aluminum outer conductor in place of the traditional all-copper outer conductor. The new cable type has RF electrical, mechanical, and environmental properties comparable to the all-copper cable type of the same size.

This paper describes the construction and properties of this new cable type, and examines the major differences between the new cable type and the all-copper cables with which the wireless infrastructure community is familiar.

Cable Construction and Features

The new cables are similar to established all-copper designs except that they use aluminum material for the outer conductor. The aluminum outer conductor is lighter than copper and is somewhat softer and more malleable. Tensile strength, crush strength, and bend moment for the cables are lower than, but comparable to, values for the corresponding all-copper cable. The dc resistance is somewhat higher than that of an all copper conductor. The dc loop resistance (inner plus outer conductors) is increased only by about 15 percent, however this does not give a significant additional voltage drop when an active component (for example, a tower-mounted amplifier) has to be powered via the coaxial RF feeder cable.

Installation trials have been performed on these aluminum cables. Reduced weight and bend moment makes them easier to handle and install than other all-copper cables, but they are still robust and withstand the stresses of installation, as verified by pre- and post-installation electrical testing.

Cable construction is shown in Figure 1 and comparisons of the key electrical and mechanical properties of aluminum cables and the corresponding all-copper cables are shown in Figure 2.

Figure 1

Specifications	*AL7-50*	*LDF7-50*
Attenuation dB/100 ft (dB/100 m) @ 2000 MHz	1.12 (3.69)	1.13 (3.70)
Attenuation dB/100 ft (dB/100 m) @ 960 MHz	.74 (2.42)	.72 (2.20)
Average Power @ 2000 MHz, kW	1.95	2.96
Average Power @ 960 MHz, kW	2.96	4.63
Peak Power, kW	302	315
Weight, lb/ft (kg/m)	.52 (0.77)	.82 (1.22)
Tensile Strength, lb (kg)	350 (159)	700 (318)
Crush Strength, lb/in (kg/mm)	75 (1.34)	120 (2.14)
Minimum Bend Radius, in (mm)	15 (381)	15 (381)
One Time Minimum Bend Radius, in (mm)	8 (200)	8 (200)
Bending Moment, lb-ft, (N-m)	30 (41)	40 (54)
Number of Bends Minimum (Typical)	15 (50)	15 (50)
Velocity (%)	92%	88%

Figure 2

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Connector Design

A connector for 1-5/8 inch aluminum cable is shown in Figure 3. Connectors are based on established designs for all-copper cables and have appropriate surface finish materials for electrochemical compatibility with the aluminum of the cable outer conductor and thus for environmental stability. The connectors can be attached using standard cable preparation tools.

Figure 3

One concern sometimes voiced about the use of aluminum as an electrical conductor in a cable is the possibility of cold flow of the aluminum (so-called "creep") under the pressure generated by a connection. This arises from the use of aluminum wire electrical conductors in ordinary building wire some decades ago with incorrectly designed fittings which would apply excessive pressure to the aluminum. The aluminum flowed, causing increased electrical resistance, and consequent overheating at the terminations caused some well-publicized fires. The cause of the problem was the use of fittings, which could not adjust to dimensional changes caused by normal ambient temperature variances. Copper and brass materials have a lower coefficient of thermal expansion than aluminum, and the pressures generated in a standard or generic fitting, as the aluminum conductor expands, are sufficient to exceed the yield strength of the aluminum and cause permanent deformation. Later, as the temperature falls and the aluminum contracts faster than the material of the fitting, contact pressure is reduced and the resistance at the contact increases.

In the case of HELIAX® connectors, attached to an RF cable with an aluminum outer conductor, the connector design is optimized and employs a compression spring-ring behind the outer conductor at the point of attachment. This provides contact pressure to the correct level, and compensates for dimensional changes due to thermal expansion, thus maintaining a consistent contact pressure over the operating temperature range. The spring-ring design also compensates for any small long-term tendency for the aluminum to flow under the applied pressure, irrespective of temperature changes.

The effectiveness of this design has been verified by extensive laboratory testing, including vibration and thermal shock, with no significant effect on return loss or intermodulation performance.

Accessories

Installation accessories for corrugated aluminum cables are universally compatible with the same sized all-copper cables. With the exception of grounding kits, existing hoisting grips, hangers weatherproofing and building entries are forward compatible. Grounding kits with factory plating for electrochemical compatibility with the aluminum cable outer conductor are reverse compatible with all-copper cables.

It is also strongly recommended that weatherproofing be used with the connectors for additional protection against water ingress, dirt, pollution, vibration and corrosion in very severe environments. WeatherShield™ shells snap in place over mated connections to provide an absolute seal against these elements and are completely reusable to reduce normal site maintenance costs.

Environmental Considerations

Aluminum is a chemically reactive metal, but in ordinary atmospheric conditions a newly exposed surface rapidly oxidizes and a thin, hard oxide coating forms and prevents further attack. Except in very severely corrosive environments, which need to be individually addressed (in situations where salt deposits can accumulate for example), the aluminum outer conductor material is environmentally stable. Aluminum cables have been used as trunk feeder cables for CATV distribution for many years.

However, aluminum is more negative on the electrochemical potential scale for metals than is copper or a copper-based alloy and, as is well known, corrosion problems can arise if such dissimilar metals are used in contact in the presence of atmospheric moisture. The moisture acts as an electrolyte and effectively a battery is created at the junction, which can cause the conversion of metal to corrosion salts. An appropriate plating (or other) surface finish material for the connector components minimizes electrochemical potential differences and any tendency for corrosion to occur. Andrew's aluminum cable products, fitted with the appropriate connectors, have undergone extensive salt fog testing to military standards and perform well.

In some locations corrosive compounds can be deposited on the aluminum conductor surface and attack it. For such conditions secondary weatherproofing should be applied over the connectors, to eliminate the corrosion mechanism. Such weatherproofing is usual practice today with copper cable installations, and provides additional protection from harsh environmental conditions

The jacket material, a high quality black polyethylene, is the same as for the all-copper cables, and the operational life for aluminum cables will be similar.

Differential thermal expansion between the copper inner conductor of the cable and the aluminum outer conductor is a major consideration in the choice of a suitable cable construction. Site locations will often see a 40 degree Celsius temperature change (72 degrees Fahrenheit) range in ambient temperature, and many will see an even larger range. For this temperature change, a 300 ft cable length will have a difference in length between conductors of 1 inch, which has to be accommodated. For longer cables the difference is proportionally larger.

For a HELIAX cable, this difference is compensated for in the corrugated outer conductor. The corrugations provide a mechanism to absorb excess length resulting from thermal expansion, and there is no undue force applied to the connectors at the ends of the cable, which would otherwise cause significant center pin movement and degradation of electrical properties.

Conclusion

All-copper feeder cables provide the best performance overall, electrical, mechanical and environmental, but with increasing copper prices they are becoming increasingly more expensive. A more cost-effective alternative is a cable with an aluminum outer conductor, which has excellent electrical, mechanical and environmental characteristics.

The complete Andrew solution is a systems approach, combining premium HELIAX® corrugated aluminum cable with Andrew's exclusive patented Positive Stop™ spring-based, continuous-force connectors.

While aluminum cable brings with it new elements of challenge, only Andrew can help ensure that your network saves you money without compromise, delivering performance and longevity that can be comparable to the higher copper standards.