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ALUMOWELD

A NEW BIMETALLIC WIRE

FOR

ELECTRICAL AND STRENGTH APPLICATIONS

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ALUMOWELD—A NEW BIMETALLIC WIRE

FOR ELECTRICAL AND STRENGTH APPLICATIONS

The rapidly growing availability of aluminum has greatly increased its use in the design and construction of electrical transmission and distribution lines. This has led the forward thinking of the Copperweld Steel Company towards developing a new bimetallic wire, Alumoweld, to combine the conductance and corrosion resistance of aluminum with the strength of steel. Alumoweld fills the requirements for strengthening aluminum-type conductors, retains the advantageous properties of aluminum, and in general, does the jobs for aluminum conductors that Copperweld does for copper conductors.

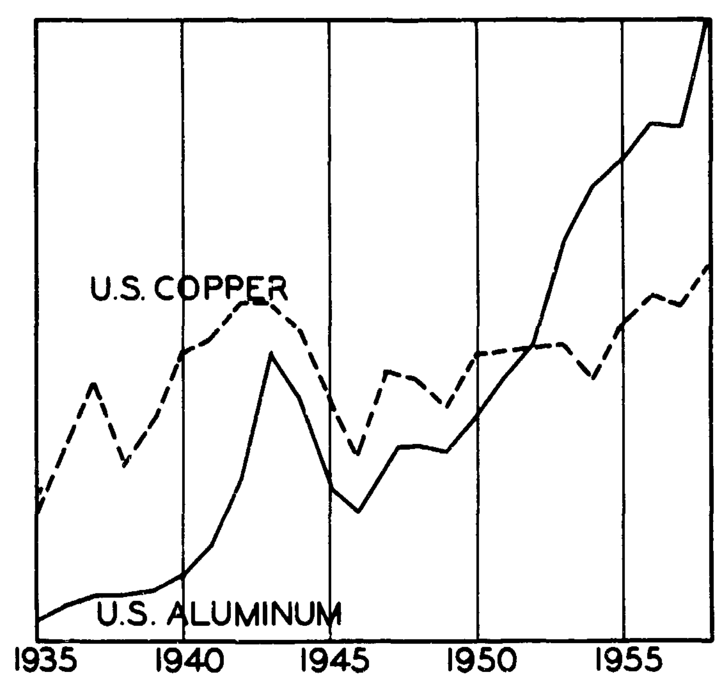


Figure 1. Production Of Aluminum And Copper In The United States.

It has been said that the best criterion for the success of a new product is whether your customers ask for the product. If this is a true index, and it probably is, the future of Alumoweld is assured. Hundreds, perhaps a thousand inquiries to the Copperweld Steel Company have said, "Why Don't You Make an Aluminum-Type Copperweld?"

Quite naturally then, work on an aluminum-covered steel wire was started several years ago. The first problem was to select a process. In the wire industry, most engineers are familiar with the manufacture of Copperweld (copper-covered steel) in which molten copper is cast around a steel ingot and the resulting large diameter bimetallic billet is hot rolled and then cold

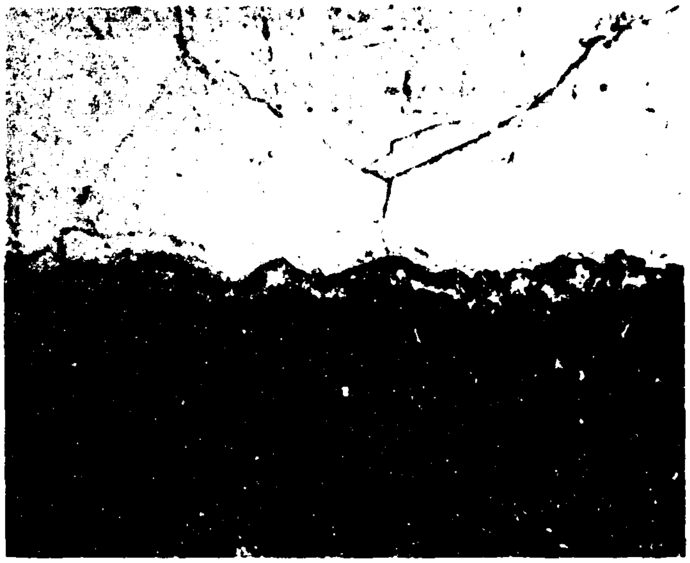


Figure 2. Microphotograph Shows Ductile Interface Alloy Formed When Copper Is Molten Welded To Steel.

drawn into wire. This process has been successful for over 40 years and has been changed only in degrees which tend towards greater economy and improved quality control. It was logical, therefore, that this process be considered in the manufacture of aluminum-covered steel wire.

Two major obstacles prevented use of the Copperweld process. The first was the low melting point of aluminum (approximately 1200°F.), which would not permit heating the steel to a temperature sufficiently high for rolling without first melting the aluminum. The second obstacle was the weld at the interface of the two metals. In copper-covered steel, the copper-iron compound formation is ductile and presents no problem. In aluminum-covered steel, the inter-metallic compound of aluminum and steel is a problem, as it is brittle. One of our major objectives was to avoid the compound, yet we knew that a metallurgical bond is essential for a wire to be drawn and to resist the normal handling abuse typical of overhead line construction. These paradoxical objectives ultimately led us to the development of a controlled weld.

The services of Battelle Memorial Institute at Columbus, Ohio, were engaged to search for the most suitable method to apply a heavy layer of aluminum over steel, and at the same time, provide a weld between the two metals without inter-metallic compound. After several early methods were explored, Battelle developed a continuous application of atomized aluminum powder metal onto steel rod, refining both the weld and the cladding with heat and pressure. The details of the process are restricted by Company policy and by patents pending, but the end results have exceeded the original hopes of the inventors and this new bimetallic rod is now being produced on a commercial basis. Also, it is being cold drawn into wires of sizes as used for overhead line applications.

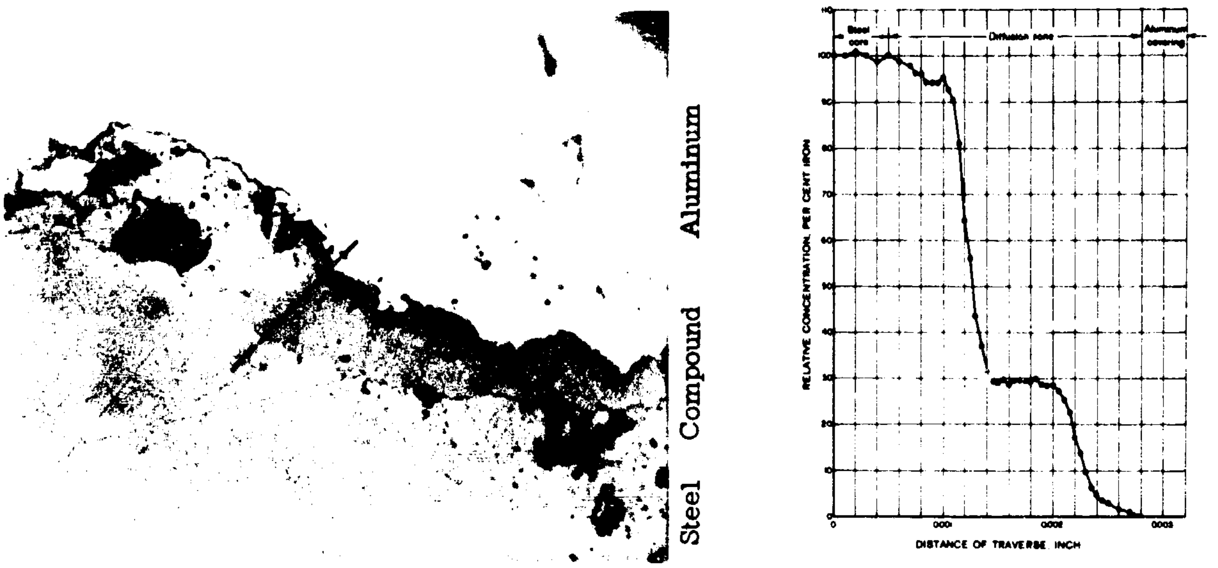


Figure 3. Electron Probe Analyzer (Traverse Line Shown By Dotted Line On Microphotograph) Measures Distribution Of Iron Across The Brittle Interface Of Early Aluminum-Covered Steel Experimental Wire.

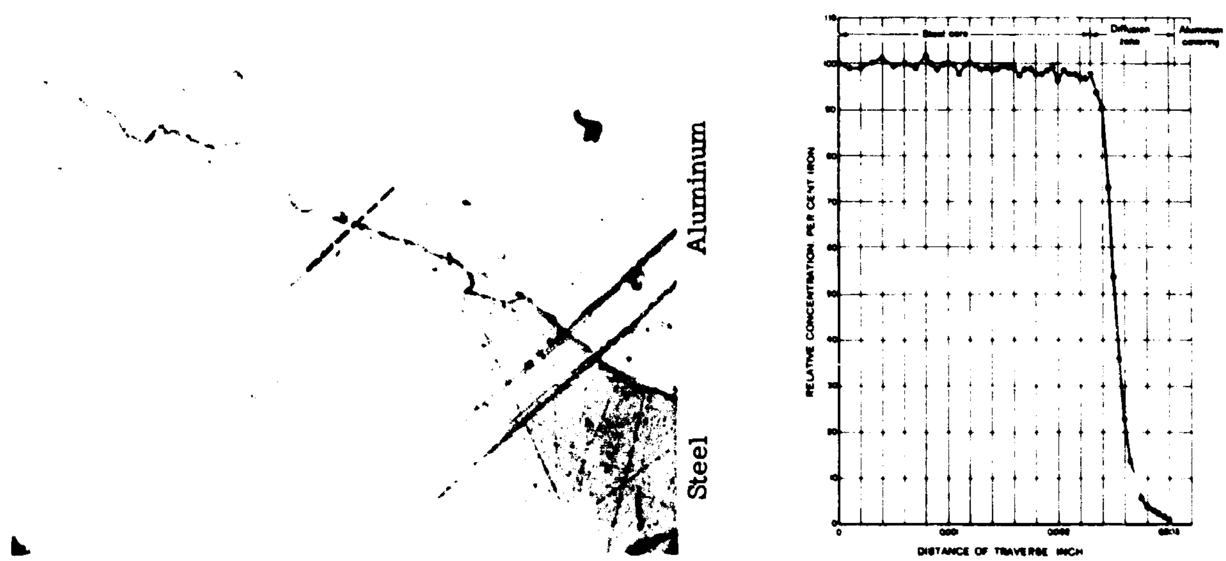


Figure 4. Controlled Weld Of Present Alumoweld Process Results In A Clean Bond Between The Aluminum And Steel Without Brittle Interface Alloy.

Experience with Copperweld over the years was helpful in deciding on the proportions of aluminum and steel. Although any reasonable proportion of aluminum and steel appears possible in the manufacturing process, the decision was made to concentrate on a design having 25% aluminum by area. The aluminum is concentrically or coaxially distributed over the outer cross section of the wire, providing sufficient corrosion resistance for field conditions. The low frequency electrical conductance is 33%, that is, three Alumo-

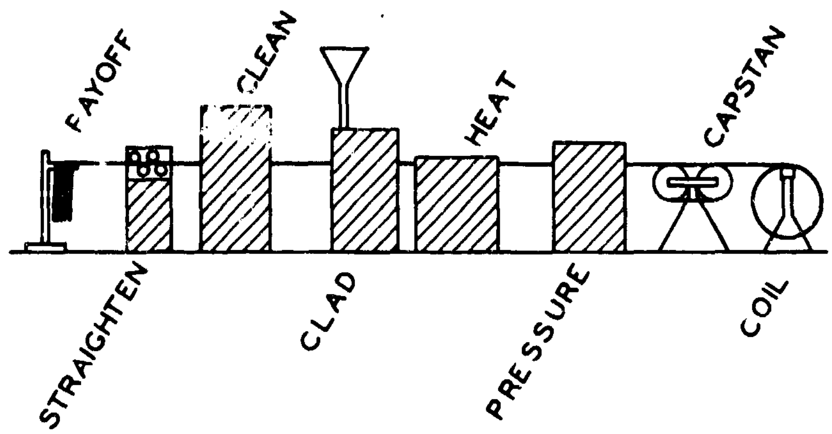


Figure 5. Schematic Diagram Of Alumoweld Production Line.

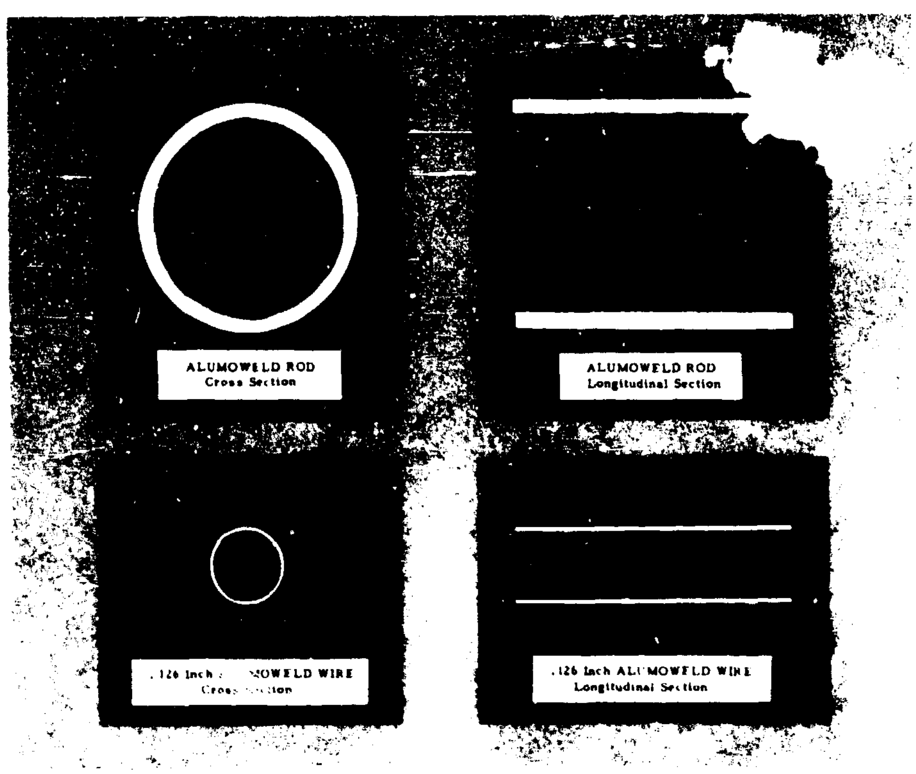


Figure 6. Proportion Of Aluminum And Steel Remains The Same After Drawing Alumoweld Rod Into Wire.

weld wires of a given diameter, when stranded together, will have the same direct current conductance as one EC aluminum wire of the same diameter. At high frequencies the conductance of an Alumoweld wire approaches 100% of pure aluminum due to skin effect.

Tensile strength of the new wire was likewise an important consideration. Early experiments taught that it was easier to clad mild steels than high-strength steels. However, for overhead line construction, the need is for high-strength steels. After preliminary trials were successful on mild steel, a high-strength steel practice was developed to give tensile strengths in the order of those already in use for extra-high-strength Copperweld or for ACSR core wire. A special aluminum powder was also developed, suitable for a continuous production operation.

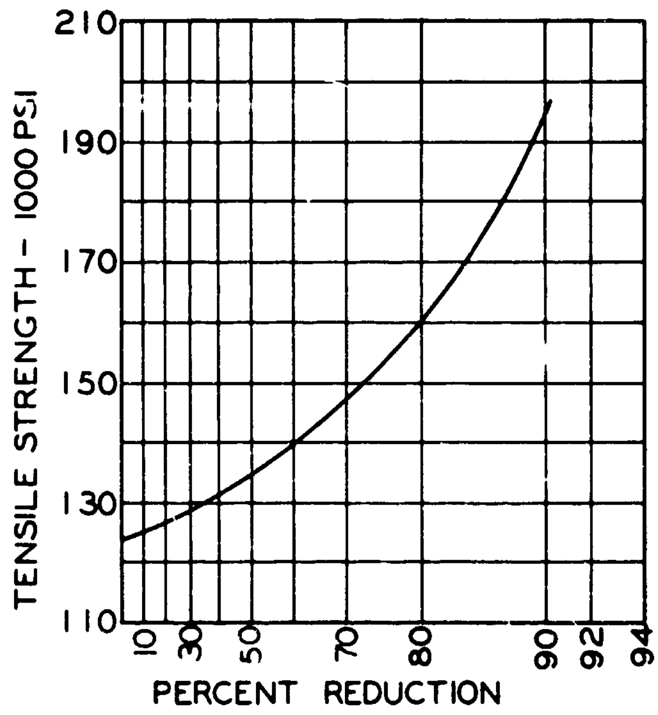


Figure 7. Alumoweld Tensile Gain Curve.

The early makers of Copperweld adopted the aim of producing a wire which would develop the same life as copper under similar exposure conditions. For Alumoweld, the designers were guided by the similar objective that this material should be satisfactory in any atmosphere where EC grade aluminum is satisfactory. Since actual field tests require a considerable lapse of time, accelerated tests on laboratory samples were the immediate answer. Salt spray tests, smoke jacket tests and 100% humidity tests, all extended many times normal expectancy, showed the Alumoweld samples to perform similarly to all-aluminum samples. Even considering the shortcomings of accelerated tests, a good confirmation of the long life of this material was established.

To be still more conclusive, notches were filed through the aluminum covering into the steel of all the Alumoweld samples, simulating the field case where a wire might be abused in installation. Such abuse is not recommended, of course, but it appears to be not even a minor hazard in this bimetallic wire because the exposed steel is apparently protected by the surrounding aluminum.

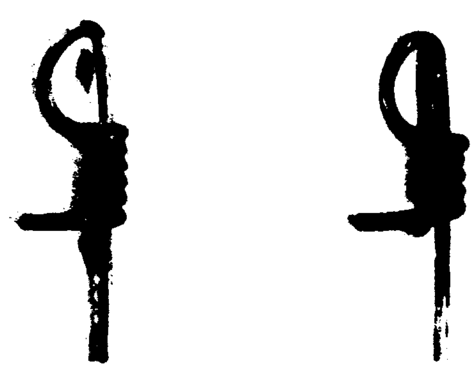
ACCELERATED TESTS SHOW SIMILAR CORROSION RESISTANCE FOR ALUMINUM AND ALUMOWELD

AL (Aluminum) AW (Alumoweld)

Figure 8. Flue Gas Tests - 1354 Hours.

AL (Aluminum) AW (Alumoweld)

Figure 9. ASTM Salt Spray Tests - 1354 Hours.



AW (Alumoweld)

Figure 10. 100% Relative Humidity Tests - 1354 Hours.

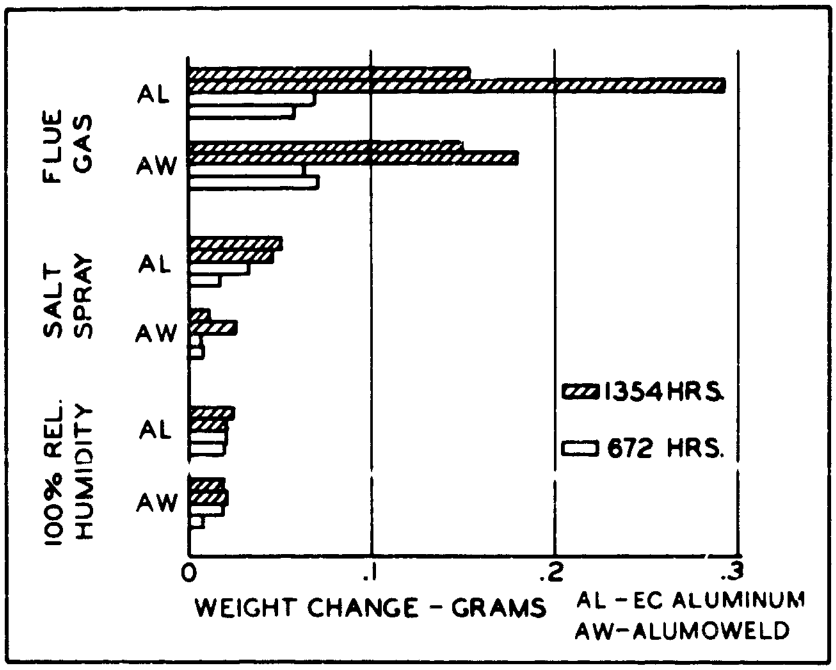


Figure 11. Quantitative Results Of Accelerated Corrosion Tests.

Having assured ourselves, there remained the evaluation of others not directly involved in the development. Samples of this wire were submitted to over a hundred laboratories and companies throughout the United States and all reports received have been favorable. The product is now marketable and can stand as a companion to Copperweld wire.

Because of its aluminum surface, Alumoweld can be applied to reinforcing aluminum conductors, where Copperweld is nct applicable. Applications fall into three classes, generally. In the first grouping are those where an aluminum surface is more or less essential. An example is core wire for ACSR conductors (aluminum wires and steel core wire or wires stranded

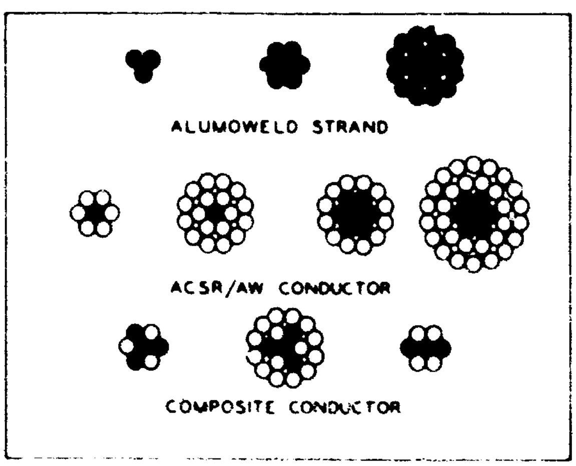
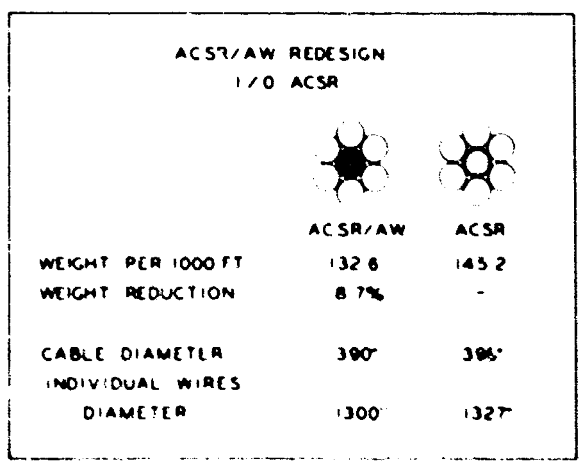


Figure 12. Typical Strandings Of Alumoweld And Aluminum Wires.



	ACSR/AW	ACSR
WEIGHT PER 1000 FT	132 6	145 2
WEIGHT REDUCTION	8 7%	-
CABLE DIAMETER	390"	396"
INDIVIDUAL WIRES DIAMETER	1300"	1327"

Figure 13. For Composite ACSR Strands, The Weight And Size Can Be Reduced Because Of Alumoweld's High Conductivity.

together). In this application, Alumoweld provides a strength member or core wire having a life similar to the aluminum wires themselves. It also eliminates dissimilar metals in contact. Such contacts, under certain circumstances, can increase the rate of corrosion. An ACSR with equally coordinated life is now a reality.

Several other advantages are noted for ACSR with Alumoweld core, known as ACSR/AW. The Alumoweld wires have a definite 25% of aluminum by area and this aluminum can be applied in the design of composite cables to marginally reduce the size of the aluminum wires, thus providing a compatible and non-rusting core with little increase in cost as compared to present designs. Another possible advantage lies in the stress-strain characteristics of the wire. In the 15% to 60% working range it is quite similar to standard ASTM core wire for ACSR and in the emergency range above 60% it can develop its ultimate strength with less permanent stretch.

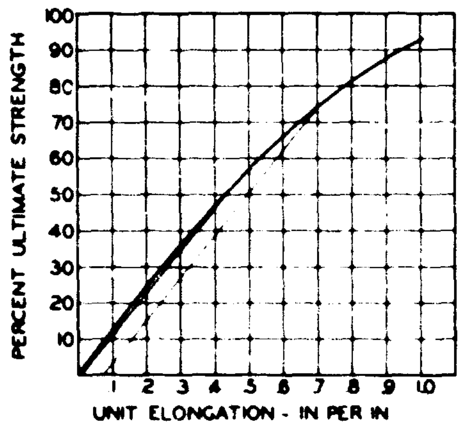


Figure 14. Stress-Strain Characteristics Of No. 8 AWG Alumoweld Wire.

Alumoweld wires may be in surface layers of ACSR strands, too. This is a relatively new concept. For example, 7-wire designs of ACSR need not be limited to the configuration of a single core wire with a layer of 6 aluminum wires over it. It now appears possible to have 2 Alumoweld wires diametrically opposite each other in the outer layer to provide added strength where required. Further, in single layer aluminum ACSR designs, the possible rusting of the core wire or wires close to the surface should not be a problem where the core wires are of Alumoweld. Another interesting Alumoweld application is for preformed armor rods and grips. These fittings may be used for dead-ending and splicing Alumoweld and aluminum-type conductors.

In the second grouping of applications are uses where both Copperweld and Alumoweld are good. Typical of these are overhead ground wire, guy and messenger strand, and fence. Here, the choice between the two bimetallic wires will depend on the application, the atmosphere, and the economics, so decisions will probably be made locally. In Alumoweld's favor is the fact that it is 20% lighter than copper or Copperweld, and its per pound cost is less. In the case of guy and messenger strand, we have been favorably impressed with the hardness developed in the aluminum covering and its resultant ability to withstand normal abuse.

There is a third group of applications where Alumoweld may not be as well suited as Copperweld. One of these is insulated line wire. The larger diameter of Alumoweld for conductance equivalent to Copperweld would appear to be an economic disadvantage. Also, if carrier or radio frequencies are involved, Copperweld will probably be superior for electrical reasons, but the choice will be close.

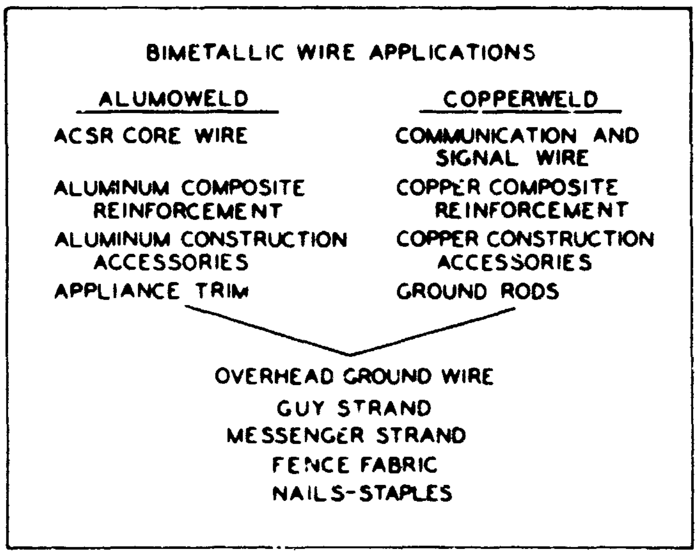


Figure 15. Alumoweld And Copperweld Applications.

At this point in the development of Alumoweld, many questions on application and design remain to be answered. Being primarily interested in high-strength electrical conductors, it is natural that we have concentrated on the overhead electrical conductor field. We recognize, however, that there are a host of applications not yet explored in both the electrical and mechanical fields. Concentrating on production has restricted experimentation, but expanding facilities now underway will soon lead into other proportions and combinations of metals as well as many new and varied applications. As of now, we are certain that Alumoweld wire is an excellent added tool for the overhead line engineer. It has the quality necessary for outdoor construction and its use will expand greatly over the years.

The physical and electrical characteristics of Alumoweld are shown on the back page. - - - - - >

ALUMOWELD T.M.

ALUMINUM-COVERED STEEL WIRE AND STRAND

Size Awg	Diameter Inch	Breaking Load Lbs.	Weight: Lbs. per 1000 ft.	Weight: Lbs. per Mile	Resistance Ohms per 1000 ft. at 68°F.	Cross Section: Cir. Mils	Cross Section: Sq. In.
3	.2294	6,201	118.1	623.4	.9691	52,630	.04134
4	.2043	5,081	93.63	494.3	1.222	41,740	.03278
5	.1819	4,290	74.25	392.0	1.541	33,100	.02600
6	.1620	3,608	58.88	310.9	1.943	26,250	.02062
7	.1443	3,025	46.69	246.6	2.450	20,820	.01635
8	.1285	2,528	37.03	195.6	3.089	16,510	.01297
9	.1144	2,057	29.37	155.1	3.896	13,090	.01028
10	.1019	1,631	23.29	123.0	4.912	10,380	.008155
3 No. 5	.392	12,230	224.5	1,186.0	.5177	99,310	.07800
3 No. 6	.349	10,280	178.1	940.2	.6528	78,750	.06185
3 No. 7	.311	8,621	141.2	745.6	.8232	62,450	.04905
3 No. 8	.277	7,206	112.0	591.3	1.038	49,530	.03890
3 No. 9	.247	5,861	88.81	468.9	1.309	39,280	.03085
3 No. 10	.220	4,648	70.43	371.8	1.651	31,150	.02446
7 No. 5	.546	27,030	524.9	2,772.	.2264	231,700	.1820
7 No. 6	.486	22,730	416.3	2,198.	.2803	183,800	.1443
7 No. 7	.433	19,060	330.0	1,743.	.3535	145,700	.1145
7 No. 8	.385	15,930	261.8	1,382.	.4458	115,600	.09077
7 No. 9	.343	12,960	207.6	1,096.	.5621	91,650	.07198
7 No. 10	.306	10,270	164.7	869.4	.7088	72,680	.05708

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