

## Aluminum Wiring by Douglas Hansen

Mention aluminum wiring and you'll find a lot of folks who react as though you've said the house has a voodoo curse. They may not understand why they're supposed to be afraid of it, but they suspect it's one of those mysterious things you're supposed to run from. I'm sure hoping that there isn't some kind of bad ju-ju on aluminum wire, because that's what they use in airplanes. I climb into an average of about three of those a week. I'll be in big trouble if that wiring doesn't work, and I'm not just referring to the darn blinking reading light.

How did aluminum get this reputation? It's actually been around for a very long time. We first see it mentioned in the National Electrical Code in 1926, with an admonition that it isn't quite as good a conductor as copper, though still much better than steel. Not much of it was used in the old days. It was a fairly rare metal, and what use folks had for it was primarily in airplanes. After WWII was over, we had finally geared up our aluminum production, and it was time for new products. In 1964, Kaiser Aluminum (part of the Henry Kaiser empire – he had been an industrialist supplying liberty ships in WWII and launched many successful ventures thereafter) produced the first aluminum nonmetallic sheathed cable. It was softer and easier to work with than copper in some ways, but it did have to be one size larger because of the lower ampacity of the wire. Soon enough, electricians all over the country were wiring houses with aluminum, and connecting it just the same way they had done with good old copper.

Some of those wiring methods were all right, but a lot of them were suspicious. In the 1960's, it wasn't uncommon to see houses wired with no wire nuts – just twisted splices covered with electrical tape, and to see "barrel crimps" used to connect a second wire to the middle of another wire (figure 1). These connections are weak – very poor by modern standards, and lots of them fail, whether they are copper or aluminum. However, the situation got a lot worse with aluminum when it was shoved into the quick-wire connections at the back of electrical devices.



Figure 1 - Arcing Barrel Crimp Connection with Copper Wire

The worst thing done with aluminum in those days was stuffing it into the quick-wire connections at the back of receptacles. A simple way to make connections in a junction box with a receptacle outlet is to feed through it, using the push-in connections in the back (figure 2).

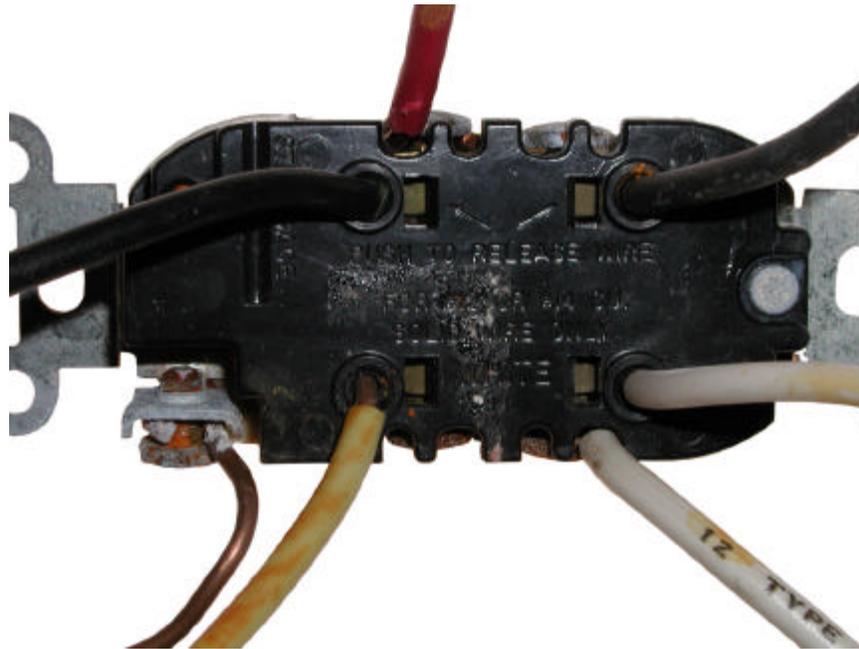


Figure 2 – Old Push-in Connections and Screw Terminal Connections

These push-in connections are bad enough with copper wire. About 10 years ago, UL changed its standards to reduce the size of these holes so that only 14 gauge wire fits into them. That way, they limit these connections to the 15 amp circuits. Of course, since aluminum wire is one size bigger than copper for the same ampacity, that meant that aluminum couldn't be used at all in these push-in connections. Nice idea, though it was 30 years late. Even before the reduction in size of these holes, the device holes were marked as "suitable for solid copper wiring only," but back in the 60's there were no such markings. Electricians just hooked up aluminum wire anywhere it would fit, doing exactly the same things they would do with copper wiring.

Such was the formula for the disasters of aluminum wiring from 1964 to 1972. They were hooking it up to devices with a different kind of metal, and the alloy they were using in the aluminum was downright inferior. There were lots of problems with the aluminum expanding while hot and contracting while cool. That's a good way to get loose connections, not to mention oxidizing and reacting to dissimilar metals. Oxidation on aluminum is a big deal because aluminum oxide (a fine white powder) is an insulator, not a conductor. Sure enough, documented aluminum wire failures in the 60's included about 155 house fires, and several deaths in Texas, New York, and New Jersey. The aluminum industry knew they had a problem, and they began the steps to correct it.

The real problem was the wire itself. Beginning in 1972, aluminum wire is a modified alloy with improved terminal retention, less expansion and contraction, and a much superior product to the material that had been placed in over 2 million homes between 1964 and 1972. Modern aluminum is an AA8000 series alloy, vastly superior to the pre-1972 material.

In 1972, the same year the aluminum wire industry introduced new alloys, congress approved the Consumer Product Protection Act, which created a new agency, the Consumer Product Safety Commission, which opened in 1973.

One of the first items to gain the new CSPC's attention was aluminum wire. The industry was able to convince the CPSC of the improvement in the new alloys, but the commission was concerned with the issue of whether the existing pre-1972 aluminum wire should be recalled. The aluminum industry faced the financially disastrous prospect of having to rewire all these houses, and searched for another solution.

Everyone agreed that aluminum by itself was an adequate conductor, but the problems at the terminations of pre-1972 "old technology" aluminum were causing fires. The aluminum industry was able to point to a solution – the "copalum" connection system from Amp Industries. With this system, a short copper pigtail was placed next to the aluminum, and a crimping die joined the two conductors with a permanent crimp. The resulting connection did not bring the copper and aluminum into direct contact – the die is actually a current-carrying component – and the connection was not plagued by the problems of joining dissimilar metals. The copper pigtail could be safely connected to a switch or receptacle like any other copper wire.



Figure 3 - Copalum Connections

Convinced that a safe alternative existed, the CPSC backed away from their investigation into a possible recall of the old technology aluminum, but not without a few other interesting developments throughout the 1970's.

Everyone realized that the problem was at the connections at the wire terminations, so they concentrated on the devices the aluminum connects to. They came up with circuit breakers, switches, and receptacle outlets identified for "Cu/Al" connections. That worked OK with circuit breakers, but the set-screw connections on the receptacles and switches were still failing. Those products were later replaced by "CO/ALR" devices.



Figure 4 – CO/ALR Receptacle

In addition to the CO/ALR receptacles, a number of other methods were attempted in the 1970's. These include connecting aluminum directly to the screw terminals of ordinary receptacles, and the use of copper pigtails with ordinary wire nuts between the copper and the aluminum.



Figures 5 & 6 – Direct Wired Aluminum and Copper Pigtail with Old Style Wire Nuts

Neither of the methods in figures 5 or 6 is recognized (unless the receptacle in figure 5 is rated CO/ALR) and the CPSC published a brochure regarding Copalum as the only known safe pigtail method. In the 1970's and 1980's, a number of contractors cooperated with the retrofit program by leasing the necessary equipment from Amp Industries. That includes the crimping dies, the tool to perform the crimp, the heat shrink tubing to insulate it, and the heat gun to shrink the tubing. This repair method was once widely available across the United States. The problem with it was that many times the connections could not all be accessed with the tools. Many "repaired" aluminum wire systems are really only partial repairs, and this method could give consumers a false sense of security. The popularity of the system waned in recent years, and today it is difficult to find contractors who can perform a Copalum repair.

Into this mix we find two other splicing methods that have a UL listing. First was split-bolt connectors (figure 7) , and the next was a wire nut by Ideal that was introduced in February 1995 (figure 8). This wire nut contains an anti-oxidant paste encapsulated inside the connector.



Figure 7 – Split Bolt Connector



Figure 8 – Ideal 65 Wire Nut

Split bolt connectors with a separating plate are very labor intensive, and require a layer of bulking tape and insulating tape. They also can easily crowd an existing box. The Ideal 65 wire nut is basically an ordinary wire nut with anti-oxidant inside it. The wire nut is not approved for aluminum to aluminum connections – one of the conductors in it must be copper. As with all these devices, their effectiveness and safety depends heavily on the quality of the workmanship – there is no “magic bullet” to assure safety in an old technology (pre-1972) wiring system.

What can a homeowner do when they discover they have aluminum wiring? Here is a suggested sequence of procedures:

- 1) Determine the age of the system. If the home was built very close to 1972, the age alone might not be sufficient to determine the type of alloy that was used. It may be possible to remove a section of a grounding conductor or other piece of wire to perform a stress test. The old technology wire will snap in half if it is bent sharply back and forth 5 or 6 times in rapid succession. The newer wire will not break so easily.
- 2) Examine the connections. Look to see the method that was used to connect to devices, and whether those devices are rated CO/ALR. Look for burn marks, charring, or any other indications of overheating, such as melted insulation.
- 3) Examine the connections in the panel. Breakers with aluminum connected to them must be rated for both aluminum and copper conductors, and the panel itself should have a label stating that aluminum is acceptable on the ground and neutral bus bars. Look for the presence of anti-oxidant paste. Another problem that might be found is loose connections inside the panel. They should not simply be tightened up – adding more torque to the terminal could drive the lug through the wire. Old wire must be cut off and stripped so a clean new connection can be made.
- 4) Test the system for voltage drop. A tool such as the Sure Test can pinpoint the presence of weak connections that could be present because of failing aluminum wire.

If the steps above indicate a problem, professional help will be necessary. In many cases, there is no practical solution short of rewiring the house. In others, you may find that the conditions do not conform to recommended standards yet they show no problem. I've seen many houses wired with aluminum in the mid 1970's that exhibited no sign of failure. Finally, aluminum ceased to be manufactured in nonmetallic sheathed cable by the end of the 1970's. It is still widely used today with stranded conductors for large branch circuits, and as feeders and service entrance conductors.

What can a home inspector do when they find aluminum wire? As much as they might like to direct their clients to a quick and certain resolution of any questions about aluminum, there are no simple answers. Home inspectors should recommend the system be evaluated by a contractor who is qualified and familiar with the problems of aluminum wiring systems. Your clients should take care to examine the contractor's qualifications. We recently found a southern California “contractor” who was using scare tactics to advertise the Copalum repair system, and the person was not even licensed.

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