



ALUMINUM ELECTRICAL WIRING

prepared by

**Fire Prevention and Investigation Division
Denver Fire Department
Department of Safety**

and

**Electrical Inspections Section
Denver Building Inspection Division
Community Planning and Development Agency**

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About Aluminum Electrical Wiring

Between 1965 and 1973, aluminum wiring was used to install electrical branch circuits in about 1.5 million homes in the United States. Subsequent fires in some of these homes were attributed to *faulty aluminum wire connections*. During this period, studies conducted by the National Fire Protection Association, in conjunction with the U.S. Consumer Products Safety Commission, revealed that homes using aluminum wires manufactured before 1972 are 55 times more likely to have one or more electrical connections reach “fire hazard” condition than homes wired with copper.

Aluminum wiring in itself is not dangerous. Aluminum wiring, when properly installed, can be just as safe as copper. But if it has not been installed properly, the *connections*—where the wires join to the outlets and switches—can present a fire hazard. This booklet provides information on the steps you can take to ensure the safety of the electrical connections in your home.

How to Tell

The wiring that is of concern involves the circuit wiring to your outlets and light switches, and to appliances that use 115 volt current, such as the furnace and washing machine. It is a single-strand, solid aluminum wire, silver in color as opposed to the characteristic copper wiring color. Most homes of any vintage employ some aluminum wiring. Often service entrance cables from the street that run to the distribution panel and major appliance circuits (220 v) are aluminum. The safety concerns are not with these cables, but rather with branch circuit connections involving the lighting and other 115 v circuits.

The Problem

Most problems arise with solid aluminum wire, sizes #10 and #12 gauge. These problems concern the ends, or terminations, of the aluminum wire, where they connect under bonding screws. If the connections are improperly installed, there is a potential for intermittent, “hot” connections where the wires join to the outlets and switches. Again, the problem is with the *connections*, and not with the wiring itself.

The main difficulty with connections using aluminum wiring is a phenomenon known as “cold creep.” Aluminum’s coefficient of expansion (how much it

expands when electrical current passes through it) is higher than copper's. Simply put, when aluminum wiring warms up, it expands more than copper does, and when it cools down, it contracts more than copper does. This expansion and contraction, over time, will allow for loosening at the connections. Also, aluminum wire needs to be larger than copper to carry the same amount of electricity. Because the wires are thicker, you cannot get the same tightness at the connections. Therefore, they may loosen more quickly.

To make the problem worse, all metals oxidize or corrode in an oxygen environment. Copper oxidation forms as a conductor, while aluminum develops as a resistor. This resistance causes heat. Oxidation accelerates when two unlike metals are in contact with each other. This may be part of the source of increased resistance when aluminum wire joins to outlets or switches intended for copper. Eventually the wire may start getting very hot, melt the insulation or fixture it's attached to, and possibly even cause a fire.

Evaluation of Your Electrical System

As mentioned above, aluminum wiring can be just as safe as copper when properly installed. Denver's Building Department has always maintained—including during the years 1965 to 1977, when aluminum wiring was being installed nationwide—a force of electrical inspectors who themselves are licensed electricians and have worked diligently to ensure that all installations comply with local and national standards. Many of the incidents publicized from other parts of the country simply don't occur here. Still, any potential electrical problem is a potentially serious problem. There are several warning signs to look for that would suggest the possibility of connection problems.

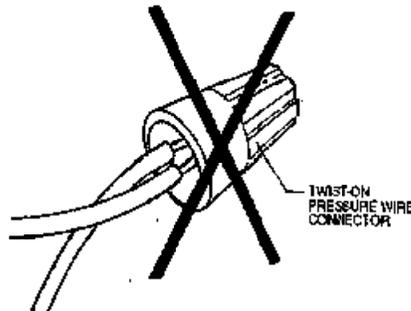
They are:

- Sparks emanating from outlets
- Warm-to-touch cover plates on outlets and switches
- Smoke coming from outlets, junction boxes or switches
- Lights that flicker for no apparent reason
- Melted insulation (plastic) at the connections
- Smell of burning plastic at outlets
- Light bulbs that burn out quickly, or shine unusually bright
- Blown fuses or tripped breakers for no apparent reason
- The size of your television picture shrinks

Making Sure It's Safe

If you're experiencing one or more of the above connection problems, or are otherwise concerned, we suggest that you hire a licensed electrician to check over the wiring for the following:

1. Outlets and switches directly attached to aluminum wiring shall be listed for that purpose. The device will be stamped with "AL/CU" or "CO/ALR." The latter supersedes the former, but both are safe. These fixtures are somewhat more expensive than the ordinary ones.
2. Wires should be properly connected (wrapped at least $\frac{3}{4}$ way around the screw in a clockwise direction). Connections should be tight. While repeated tightening of the screws can make the problem worse, during the inspection it would pay off to have the electrician "snug up" each connection.
3. "Push-in" terminals (terminals where the connecting wire is pushed into a slot rather than wound around a screw) are an extreme hazard with aluminum wire. Any connections using push-in terminals should be redone with the proper screw connections immediately.
4. There should be no signs of overheating -- darkened connections, melted insulation, or "baked" outlets or switches. Any such damage should be repaired.
5. Connections between aluminum and copper wire need to be handled specially. Current Denver City Ordinance requires that the connectors used must be specially marked for connecting aluminum to copper. The National Electrical Code requires that the wire be connected together using special crimp devices, with an antioxidant grease (see "[Repair Options](#)," over).
6. *National Electrical Code*, Sections 110-114 and 310-14 address electrical conductors of dissimilar metals and prohibits the use of unlisted twist-on connectors for connection of copper and aluminum wiring.

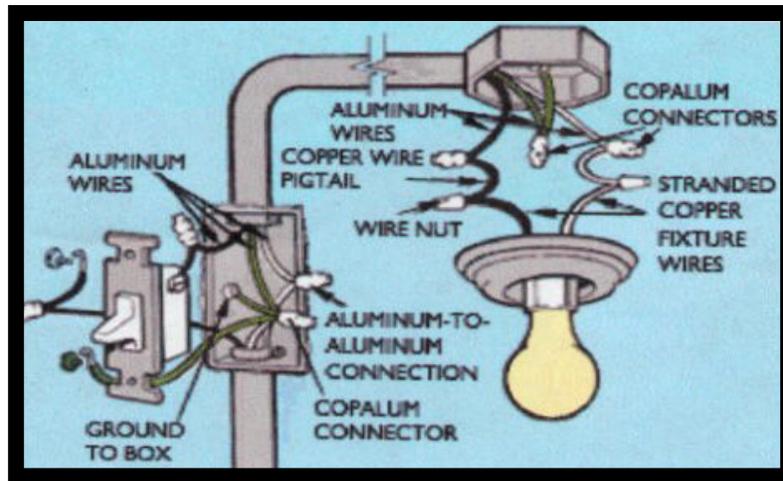


Repair Options

It is very unlikely that the aluminum wiring in your home needs to be removed. While total rewiring would remove all risk and concern—but at great expense—there are other options available. They include:

- The preferred method for handling a connection between aluminum and copper wire, as recommended by the National Fire Protection Association, Underwriters' Laboratories and the U.S. Consumer Products Safety Commission, is to make a pigtail connection using the "Copalum crimp method" developed by Amp, Inc. In this repair, the aluminum wiring is "crimped" with copper, using special connectors and an antioxidant compound. The connection is then covered with heat-shrunk insulation. The crimping creates a molecular bond between the added piece of copper wire and the aluminum; the short piece of copper wire connects the aluminum with the connection device. Do not confuse this with ordinary "pigtailing." There is a substantial difference. While this will potentially solve any aluminum/copper wire problem, it is somewhat expensive (\$12-\$16 per connection).
- Replacing all outlets and switches with devices marked AL/CU or CO/ALR also will make the system safe. These special outlets and switches are made with a metal that is compatible with both copper and aluminum. It will cost approximately \$7 to \$9 per device to switch over. The Denver Fire and Building Departments recommend this approach in most cases.
- You may also choose to have an electrician apply antioxidant to, and simply tighten, all connections. This makes the wiring safe—However, all connections must be retightened every two years. Therefore, in most cases we would not recommend this approach.
- Have your electrician check all connections. Replace any that use "push-in" terminals with the standard type. If any connections are loosening, they should be tightened and any oxidation should be cleaned away.

Choose the method most comfortable for you. All will render the wiring safe when properly done. However, please keep in mind that working with electricity is potentially very dangerous. Working with aluminum wiring is more difficult than working with copper, as it is more brittle and therefore breaks easily.



Correct Method

A Final Caution

The United States Fire Administration reports that annually, of the nearly 800,000 residential fires nationwide, approximately 75,000 began in the home's electrical distribution system -- that is, in the circuit wiring, receptacles, switches, cords and plugs. When a part of this network fails or is misused, a fire may result. Many of these fires were attributed to "old technology" aluminum branch circuit wiring.

Of the fires involving "old technology" aluminum branch circuit wiring, 75 percent of the incidents involved receptacles, 12 percent involved panel equipment terminals, and 10 percent involved twist-on connections. Fire investigators, including those of the Denver Fire Department's Fire Prevention and Investigation Division, determined that "old technology" aluminum-wired receptacles and twist-on connectors, when used with aluminum wire, were failure prone, even when installed carefully in accordance with the manufacturer's instructions.

Leave aluminum wiring safety improvements to licensed electrical contractors. Work done under City permit will be monitored by Denver Building Department electrical inspectors.

Any time you suspect unusual heat or smoke generated from the electrical system in your house, do not hesitate to call Denver Fire Dispatch via 911. Dispatch will direct a Fire Company to respond, investigate and evaluate conditions. There is never a charge for this service. The safety of your family and your property is our primary concern.