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ALUMINUM WIRING

The words "aluminum wiring" are often alarming to many homeowners and home buyers. This reaction is unwarranted and premature unless certain conditions which can affect the safety of specific applications of aluminum wiring are present. It is far more productive both to understand certain properties or characteristics of aluminum wiring and to have some background information regarding when and why aluminum wiring was once accepted and widely used in residential wiring systems as well as to know why its use was eventually restricted.

Aluminum wiring still meets present day industry standards as well as most local codes in specific and limited residential applications because it is still considered to be safe and adequate in those particular applications.

Aluminum wiring was widely installed in 120 volt (nominal) general lighting, receptacle outlet, and small appliance circuits in residential electrical systems from about the mid-1960s until the mid-1970s when its use was limited to incoming electrical service conductors and 240 volt (nominal) dedicated circuits. During this approximate ten-year period aluminum wiring was used because it was less expensive and more readily available than copper wiring. However, by the mid-1970s, it became apparent that aluminum was less than ideal as a wiring material in certain residential wiring system applications.

It was found that aluminum has certain physical properties or characteristics which make it less "user friendly" than copper for use in specific wiring applications. Among those characteristics are:

- Higher resistance to electrical current flow
- Lower ductility
- Incompatibility with certain other metals
- Greater vulnerability to physical / mechanical damage
- Adverse effects due to oxidation
- Thermal sensitivity (undesirable expansion and contraction qualities when subjected to changes in temperature)
- Pressure / deformation sensitivity

All of these properties, if not clearly understood and respected by anyone working with aluminum wiring, have the potential to create conditions that may damage the wiring and/or connected electrical devices and lead to overheating and/or electrical arcing in the area of the wiring damage.

The primary potential safety issues associated with improper electrical wiring conditions, regardless of the wiring materials used, are excessive heating due to high resistance to electrical current flow, electrical arcing, and electrocution.

Let's more closely examine the properties of aluminum wiring that make it less user friendly than copper for use in residential 120 volt (nominal) general lighting, receptacle outlet, and small appliance circuit wiring.

RESISTANCE

Aluminum's inherently higher resistance to electrical current flow (it is approximately 40% less conductive than copper) requires the use of larger gauge (diameter) wiring than would be necessary if copper wiring were used for the same circuit. For example: on a 120 volt (nominal) circuit that is rated for 15 amperes, a number 14 gauge copper wire is used. However, a number 12 gauge (larger diameter) aluminum wire would be required for the same circuit. Use of any wire which is underrated for its application increases the potential for overheating of the wire due to having too much resistance to electrical current flow.

DUCTILITY AND MALLEABILITY

Ductility refers to the ability of a metal to be pulled into thin wires. Malleability refers to the ability of a metal to be hammered and "worked" into thin sheets. While aluminum is more malleable than copper, it is less ductile than copper. This means that, when aluminum is subjected to physical/ mechanical stress such as repeated bending or over-bending (bending the wire in a tight radius), it will fracture, fatigue, and break more readily than copper. Therefore, much greater care is required when working with aluminum wiring. As aluminum wire is repeatedly bent or over bent, it fatigues as it breaks down internally. This, in turn, significantly increases its resistance to electrical current flow and results in overheating in the area of fatigue.

INCOMPATIBILITY

When a more noble metal comes into contact with a less noble metal in the presence of an electrolyte, a reaction known as "galvanic corrosion" can occur. Aluminum is incompatible with certain other metals. Therefore, care must be taken to determine the compatibility of the component material of receptacle outlets, switches, and other electrical devices to which aluminum wiring is connected. If aluminum wiring is placed in contact with an incompatible and more noble metal and an electrolyte is present even in a small amount, the aluminum will corrode. This corrosion damage can result in increased resistance to electrical current flow and, just as with fatigue damage, overheating and/or electrical arcing in the corroded area can occur.

Aluminum wiring should only be connected to electrical devices clearly labeled, designated, or specified by the manufacturer for use with aluminum wiring. CuAl and COALR are two common designations that are used to indicate that an electrical device is suitable for use with either copper or aluminum wiring.

MECHANICAL DAMAGE

Aluminum is more susceptible or vulnerable to physical/mechanical damage than copper. This means that a greater degree of care is required when working with aluminum wiring to avoid nicking or otherwise damaging the wire. When any wire is nicked, its thickness or diameter is reduced at the point of damage and, as with fatigue and galvanic corrosion, increased resistance to electrical current flow and overheating and/or electrical arcing can occur at the area where the wire is nicked or damaged.

OXIDATION

Oxidation occurs on the surface of a metal when the metal reacts with oxygen in the air under certain conditions. Some metal oxides such as copper oxide have a low electrical resistance and are electrically conductive while other metal oxides such as aluminum oxide have a high electrical resistance and reduce electrical conductivity. Aluminum oxide forms as a whitish powdery substance on the surface of aluminum when aluminum is exposed to air. When aluminum oxide is present on aluminum wiring, increased resistance to electrical current flow and overheating and/or electrical arcing can occur at connections of the wiring to other wires or to electrical devices. Therefore, certain measures must be taken when working with aluminum wiring to reduce the potential for oxidation. This includes following all requirements for cleaning the surface of wires, coating them with an electrically conductive, non- flammable or low flammability rated anti-oxidant compound, and working the compound onto the surface of the wire with a fine grit abrasive cloth or paper.

TEMPERATURE SENSITIVITY

Both aluminum and copper expand and contract with increases and decreases in temperature. The specific measure of this property is expressed as the individual material's thermal coefficient of expansion. The thermal coefficients of expansion of aluminum and copper are different. While increases in electrical current flow and/or rises in air temperature cause the diameters and lengths of both copper and aluminum wires to increase and decreases in electrical current flow and/or decreases in air temperature result in reduction of the diameters and lengths of both wiring materials, aluminum experiences significantly greater thermal expansion and contraction than copper under similar conditions of fluctuations or variations in electrical current flow and/or air temperature. This property of aluminum becomes potentially problematic at splices of aluminum wires and at connections of aluminum wire to the terminals of electrical devices.

There is a tendency for aluminum wire to physically move at such splices and connections as the wire expands and contracts. This movement, referred to as "creep," can cause the wire to become loose at its splice or connection. A loose splice or connection results in reduced contact between the aluminum wire and the other

wire(s) or components to which it is connected. This, in turn, results in increased resistance to electrical current flow and overheating and/or electrical arcing at the loose splice or connection. The tendency of aluminum to creep and aluminum's greater susceptibility to physical/mechanical damage are two good reasons why aluminum wire should never be connected to a receptacle outlet or switch by inserting the wire into "push-in," "bayonet"," or "stab" type connections found on the back of some receptacle outlets and switches.

PRESSURE SENSITIVITY/FLOW

Because aluminum wire is softer or more malleable than copper wire, aluminum wire has a tendency to deform when it is compressed too tightly under a screw terminal of an electrical device. Aluminum wire will creep, by continuing to deform after a screw terminal has been over tightened. This is another way that a loose connection of aluminum wire to an electrical device terminal can occur and, as with any loose electrical connection, the resistance to electrical current flow increases and overheating and/or electrical arcing can occur.

SUMMARY

All of the properties or characteristics of aluminum wiring discussed above are associated with an increased potential for overheating and/or electrical arcing at connections of aluminum wiring to other wiring or to electrical devices – not along the unexposed and continuous sections of the wiring.

The simple presence of aluminum wiring in 120 volt (nominal) general lighting, receptacle outlet, and small appliance circuits does not mean that any or all of the potential conditions which can result from the improper installation of aluminum wiring will be present in a particular residential electrical system. Where aluminum wiring has been installed or modified by a qualified professional, familiar with all of the properties of the material, and in accordance with all manufacturers' instructions, all applicable industry standards, and all applicable governmental codes, ordinances, and regulations regarding the installation of aluminum wiring, it is not considered to be hazardous.

As discussed in the beginning of this article, the use of aluminum wiring in residential electrical systems was restricted in the mid-1970s when its use was no longer permitted in 120 volt (nominal) general lighting, receptacle outlet, and small appliance circuits. However, aluminum wiring was still acceptable and remains acceptable for use in service wiring (the wiring between the electrical service provider's transformer and a home's electric meter), wiring between the electric meter and the main electrical distribution panel, and in 240 volt (nominal) dedicated circuits such as those which supply electrical power to electric water heaters, electric furnaces, heat pumps, central air-conditioner compressor units, electric ovens, electric ranges, spa, sauna, and swimming pool equipment, and between main electrical distribution panels and sub panels.

If modification of aluminum wiring is performed to reduce potentially hazardous conditions at aluminum wiring connections to electrical devices, it is not necessary to remove or replace all of the wiring in the home. The two methods used to modify aluminum wiring at connections to electrical devices are commonly referred to as "pigtailing" and "crimping." Both methods involve the disconnection of aluminum wiring from the electrical device and attaching one end of a short piece of copper wire to the aluminum utilizing an approved wire nut type connector or a connector such as those marketed under the brand name AlumiConn™ then connecting the other end of the copper wire to the electrical device. Over the past thirty years improvements in both methods have been made.

Both pigtailing and crimping must be done by a qualified and licensed electrical contractor.

COST

The costs associated with both methods of aluminum wiring modification are typically based on a per-device basis for receptacle outlets, switches, transformers, fixtures, as well as for overcurrent devices in electrical circuit breaker and fuse panels. The pigtailing method is typically less expensive than the COPALUM Crimp Method and can be applied to a single electrical device or to as many as is desired or necessary.

If the COPALUM Crimp Method is used, the AMP Corporation requires that its licensees modify **all** 120 volt (nominal) electrical devices and all electrical distribution panel 120 volt (nominal) circuit breaker devices and fuses that are directly wired with aluminum wiring in an electrical system.

A FINAL WORD

Become familiar with your home's electrical system. Know where your circuit breaker or fuse panels are located. Know how to shut off the power to individual circuits and to the entire system. Make sure that all circuits are accurately and permanently labeled in the circuit breaker or fuse panel. If any 120 volt (nominal) general lighting, receptacle outlet, and /or small appliance circuits are wired with aluminum wiring and that wiring has not been modified by one of the methods described in this article, it is strongly recommended that all aluminum wiring

terminations, splices, and connections be periodically examined by a qualified and licensed electrical contractor for any loose connections or components and for any evidence of overheating, arcing, scorching, or damage.

All electrical work involving the removal, replacement, or modification of any electrical splices or devices, including receptacle outlets, switches, transformers, overcurrent devices (circuit breakers and fuses), distribution panels, meters, meter housings should be performed only by a qualified electrical contractor and in accordance with all applicable industry standards and all applicable governmental codes, ordinances, and regulations.

Regardless of the type of wiring that is used in a residential electrical system, if any of the following occur, shut off the affected circuit and contact a qualified electrician as soon as possible to have the circuit checked for any necessary modifications or corrective measures.

- REPEATED FLICKERING OF LIGHTS (NOT DUE TO LOOSE OR DEFECTIVE BULBS)
- STATIC ON TELEVISIONS, RADIOS, OR OTHER ELECTRONIC DEVICES (NOT DUE TO INTERFERENCE FROM OTHER ELECTRICAL EQUPIMENT OR DEVICES)
- SWITCHES, RECEPTACLE OUTLETS, OR THEIR FACE COVER PLATES WHICH ARE OVERLY WARM OR HOT TO THE TOUCH (SOME DIMMER SWITCHES WILL NORMALLY BE WARM WHEN PERFORMING THEIR DIMMING FUNCTION BECAUSE THEY INCORPORATE AN INTERNAL RESISTANCE DEVICE)
- ANY SWITCH, RECEPTACLE OUTLET, OR JUNCTION BOX PLASTIC COVER PLATE THAT HAS BECOME BRITTLE
- BUZZING, SNAPPING/ARCING SOUNDS AT RECEPTACLE OUTLETS OR SWITCHES
- LOOSE OR WORN RECEPTACLE OUTLET BLADES (THE INTERNAL PARTS IN A RECEPTACLE OUTLET THAT CONTACT AND GRIP THE PRONGS ON A PLUG END WHEN THEY ARE INSERTED INTO A RECEPTACLE OUTLET)
- WORN OR LOOSE SWITCHES
- SPARKING, SMOKE, OR THE ODOR OF HOT, SCORCHED, OR BURNED MATERIALS