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The Locomotive

Fundamentals of Aluminum Conductors, Part 2: Installation and Maintenance

By John Roach, The Hartford Steam Boiler Inspection and Insurance Company

Introduction

The increased use of aluminum conductors in the 1960s and 1970s led to millions of dollars in electrical breakdown claims for Hartford Steam Boiler and many millions more in fire losses for property insurers. These claims were primarily the result of failures of aluminum connectors or connections. But, the proper preparation and installation of aluminum conductors can reduce or even eliminate this type of failure. Part 1 of this article addressed the characteristics of aluminum conductors. Part 2 discusses proper installation and maintenance.

Aluminum Wiring Hazards

In the 1960s and early 1970s, aluminum conductors were used extensively for residential and commercial buildings. This was primarily because of their lower costs as well as their strength and weight advantages. During this time period the conductors were made from the aluminum alloy series 1300, which is essentially 99 percent pure aluminum.

The mechanical properties of this alloy were not considered when terminating these conductors. As a result, heating and corrosion issues occurred. These heating and corrosion issues led to an increase in the risk of electrical fires. Warning signs include warm-to-the-touch face plates on outlets or switches, flickering lights, circuits that don't work, or the smell of burning plastics. These signs can indicate a fire hazard within 15- and 20-ampere aluminum wiring circuits.

A failure in the circuits can lead to electrical arcing and a serious fire, which can spread within the walls of a building before being detected. A qualified electrician trained in inspecting for aluminum wiring hazards can assist in identifying potential aluminum wiring hazards.

HSB Recommended Practice

Hartford Steam Boiler Recommended Practice for branch circuits with the "old" aluminum wiring (circuits installed between 1965 and 1972) is the following:

- The best solution is to discontinue the use of the circuit with aluminum wire, and replace the aluminum wiring.
- Since replacing the aluminum wiring may not be economically feasible, a second-best alternative is installing "pigtails" (a short copper connecting wire) between the aluminum wire and the wired device (receptacle, switch, fixture or breaker). The pigtail connection must be made using either the COPALUM crimp connector, or the King Innovation® AlumiConn® connector.

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Aluminum Connections

The COPALUM crimp connector (see figure 1), which has been available for more than 20 years, is the only system recognized by the U.S. Consumer Product Safety Commission that provides a complete and permanent repair and reduces the fire hazard in aluminum wire circuits. The COPALUM connector system attaches a copper wire to the old aluminum wires and is then crimped together with a power tool, achieving a "cold weld" between the conductors.

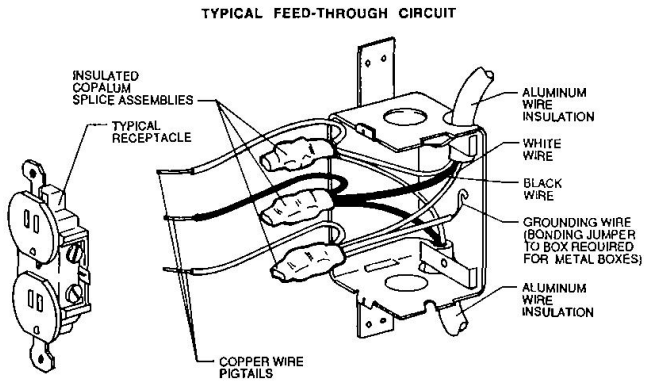

Figure 1

The cold weld creates a permanent bond that eliminates electrical arcing or glowing connections and creates a safer electrical connection at outlets, switches, lights, circuit breakers, and panelboard terminals. The COPALUM connector repair materials and power crimping tools are only available to electricians who receive training from the manufacturer, to ensure that repairs are properly made. COPALUM connectors are available from Tyco Electronics under the AMP brand. To order a list of authorized COPALUM electricians in your area, write to: Tyco Electronics Corp., Attn: Aluminum Wire Repair Program, P.O. Box 3608, Harrisburg, PA 17105-3608.

The King AlumiConn® Aluminum to Copper Lug connectors [New in 2006, UL Listed, 2007 completed independent testing] is available from King Innovation. Results of independent testing indicate that this product "... is predicted to have a high probability of failure-free long-term safe performance, provided that the setscrews are carefully tightened to the manufacturer's recommendation."

The following are NOT acceptable repairs:

- Installing pigtails with conventional "wire-nuts" (see figure 2) is NOT acceptable — even if it is "UL listed."
- Simply replacing old fixtures or receptacles with those marked "Cu/Al" is not acceptable.
- 3M Scotchlock® connectors.

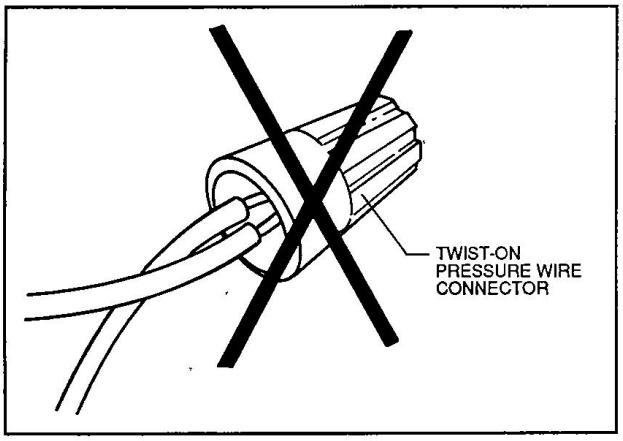

Figure 2

Current Wiring Practice

The aluminum alloy series 8000 became available for use in electrical conductors in the mid 1970s and is still in use today. The 8000 series has improved mechanical characteristics as compared to aluminum alloy 1300 series and retains the weight and cost advantages of aluminum over copper.

Today most electrical equipment and connectors are rated for both copper and aluminum conductors. The connection process is straightforward: it includes the use of suitable connectors, an oxide inhibiting compound, proper hardware and appropriate torque wrenches. Follow the instructions from the connector manufacturer.

The suitable connector is usually designated with a CUAL or an ALCU stamp. They are normally made of a base material and plated to ensure compatibility. Oxide inhibitors are used to seal the connection area thus minimizing oxidation from occurring while in service. The proper hardware is critical due to different creep rates and different thermal expansion rates.

For bolted connections, a cone shaped spring washer, commonly known as a Bellville washer, should be used to maintain pressure and prevent loosening of hardware due to the different thermal expansion rates. When tightening connections, an appropriately sized torque wrench and the manufacturer specified torque value should be used. Remember, exceeding the recommended torque value is just as damaging as not obtaining the minimum torque value.

The Connection Process

Below are basic procedures that should be followed when making connections. These procedures are for guidance only and the manufacturer's instructions for the connectors that are being used should be followed.

Mechanical Compression Connectors

- Connectors should be dual rated by Underwriters Laboratories (UL) for use with copper or aluminum.
- Connectors should be sized appropriately for the amperage.
- Lug barrels should be pre filled with an oxide inhibiting compound listed by UL.
- Wire insulation should be removed using an appropriate stripping tool.
- Oxide layer of the wire strands should be removed from the wire surface with a wire brush.
- Crimp the connectors using the correct dies in accordance with (IAW) manufacturing instructions.
- Clean off any excessive compound.

Mechanical Screw Type Connectors

- Connectors should be dual rated by UL for use with copper or aluminum.
- Connectors should be sized appropriately for the amperage.
- Wire insulation should be removed using an appropriate stripping tool.
- Using a wire brush remove the oxide layer from the wire surface and apply UL listed oxide inhibiting compound.
- Tighten the connectors IAW manufacturing instructions to the proper torque value
- Clean off any excessive compound.

Termination of Aluminum Conductor to Aluminum Bus

- Prepare any required mechanical connections IAW above instructions.
- Ensure the two mating surfaces are clean and flat with no burrs present and coat with oxide inhibiting compound.
- Required hardware:
  1. Bolts: anodized aluminum alloy 2024-T4.
  2. Nuts: heavy hexagon with coarse threads.
  3. Washers flat and lock of aluminum alloy.
- Lubricate with compound, tighten and torque hardware IAW manufacturer instructions.

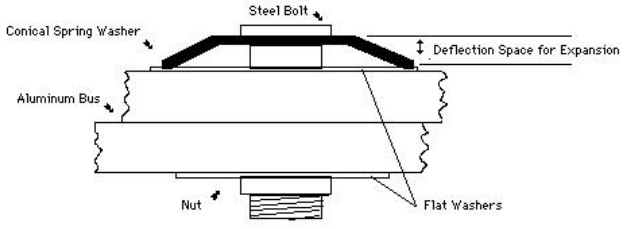

Figure 3

Conclusion

A sound, reliability based maintenance program incorporates operating history, operational characteristics and environmental conditions. The same principles apply for a system containing aluminum conductors. The use of aluminum conductors does not require any unique inspections or an increased frequency of inspections. Items to check during a visual inspection which could indicate a potential problem include but are not limited to, signs of arcing; cracking or excessive heat; use of properly rated lugs; signs of corrosion; use of Bellville washers as appropriate; and signs of over or under compression of the Bellville washers.

About the Author

John Roach is a principal electrical engineer with The Hartford Steam Boiler Inspection and Insurance Company. John has a B.S. degree in Electrical Engineering from the University of New Haven and a Master's of Engineering degree in electrical power engineering from Rensselaer Polytechnic Institute. He has almost 20 years of industrial electrical engineering experience and is an active member of the Institute of Electrical and Electronics Engineers, Inc. (IEEE).