PowerCheck
Electrical Safety Services

#300–3665 Kingsway, Vancouver, BC V5R 5W2
Phone: 604.684.3630 (Vancouver)
Toll Free: 1.800.517.3630 (Canada)
Email: info@powercheck.ca
www.powercheck.ca

Hazards of Electrical Wiring in Older Buildings

by Brian Cook

Leading Causes of Electrical Fires

"Knob-and-tube wiring", "aluminum wiring", "60-amp electrical service" and "fuse boxes" have been the common indicators of homes with potentially high risks. Surprisingly, these components of the original wiring system are usually not the culprits of electrical fires, nor are they the best indicators if electrical fire hazard conditions are present. Though old and often well used, if the original electrical system has not been abused, for example by over-rating fuses or circuit breakers, or by cutting the original conductors to add on new circuits, the original electrical system will likely be found today to be in excellent condition. Focusing on these elements of the electrical system can easily miss the real electrical fire hazards.

Study after study show, the vast majority of electrical fires in homes are a result of "handyman tinkering", that being unauthorized individuals having made changes or additions to the original electrical system; changes or additions that were not in compliance with the electrical code. Handyman tinkering was particularly prominent in the 1960s, '70s, '80s and the '90s during time of home renovation. Faulty circuit breakers also play a significant role in causing electrical fires. One test conducted in

Broken ground due to water pipe repair with PEX

Faulty circuit breaker

British Columbia in the 1970s found that circuit breakers over 15 to 20 years old were faulty, resulting in electrical fires. Deterioration of electrical conductors does occur if subjected to electrical or physical abuse, regardless of conductor type. Modern electrical cables are just as often found to be in a state of peril as are knob-and-tube conductors. Live electrical cables dangling in basements, from disconnected electric water heaters, disconnected when the electric water heater was replaced with a gas heater are often found.

Hazards associated with handyman tinkering are a result of unqualified individuals incorrectly adding extra circuits, or by altering existing circuits without adherence to the electrical code. Common examples include:

- Electrical splices not contained in an electrical junction box
- Poor electrical connections
- Undersized extension cord stapled to a wall
- Oversized circuit breakers
- Incorrect cables providing power to the garage
- Baseboard heaters installed in hazardous locations. Occasionally found in contact with flammable materials
- Use of broken and deteriorated extension cords
- Overloading of circuits with heat producing equipment
- Stapling extension cords to walls, baseboards and under eves (for the wiring of outdoor Christmas lights).
- Running electrical cords under carpets or in high traffic areas.

Knob-And-Tube Wiring

Knob and tube was the standard wiring in all homes built pre-1950, and is still present to some degree today in the vast majority of occupied houses today built pre-1950. Installation of a new electrical service or new electrical panel does not assure elimination of knob-and-tube wiring. Usually when new panels are installed, knob-and-tube wiring in the vicinity of the panel is replaced. However, live knob-and-tube still continues downstream, providing power to receptacles and lights. If the basement has been finished it is highly possible that all visual signs of knob-and-tube have been concealed.

Knob-and tube wiring was a well engineered system. It consists of rubber-insulated electrical conductors wrapped in a flame-retardant cloth that are supported and secured throughout the house by porcelain knob and tubes. The conductors were of heavy gauge copper. As a result, compared to the cable commonly used in the wiring of modern houses (NMD90) the knob-and-tube conductors dissipate less heat. The conductors were well spaced, usually at 8 inches along the runs throughout the house. Spacing the conductors far apart from each other eliminated the opportunity for short circuits to occur along the length of the conductor runs.

In addition, to assure that electrical splices (electrical wire to wire connections) were sound, all splices were soldered. Soldered connections minimize the opportunity for connections to become loose and arcing to occur. Finally, a key point of knob-and-tube installations is that the wiring installation was seldom done by nonprofessionals.

Knob-And-Tube Safety Concerns

Knob-and-tube wiring is occasionally found to be hazardous and does require replacement. The three common concerns associated with the knob-and-tube circuits are:

(i) insulation deterioration
(ii) "handyman add-ons" and
(iii) ungrounded 3-prong receptacles

(i) Insulation Deterioration:

Insulation deterioration along the length of the run is a result of overcurrent on the conductors. For example: If the occupant uses multiple heavy loads on one circuit (e.g. motors and compressors), he may experience tripping of the overcurrent device (fuse or circuit breaker). The correct solution will be to have a licensed electrical contractor install a new circuit from the panel for the additional electrical appliance. If however the occupant, in error, exchanged the15-amp fuse or circuit breaker with a larger 20 or 30 amp fuse or circuit breaker to "rectify the problem", the fuse will not trip under the high loading conditions. Overcurrent will occur, which will be followed by insulation deterioration on the conductors. Overcurrent will break down the conductor insulation whether knob-and-tube or otherwise.

(ii) "Handyman add-ons":

"Handyman add-ons", that being electrical additions to the original electrical system creating a dangerous situation, are occasionally found tapped onto original knob-and-tube wiring. Instead of the circuit running back to the panel, as should have been done, circuits are found spliced onto the original knob-and-tube conductors. This action is a complete disregard for electrical safety, and can result in arcing followed by fire. If identified these dangerous add-ons must be removed.

(iii) Ungrounded 3-prong receptacles:

Knob-and-tube wiring was designed to provide power to 2-prong "old-style" receptacles. These receptacles did not provide ground protection. Knob-and-tube was phased out by the early 1950s, however ungrounded receptacles (2-prong outlets), wired by a newly introduced twin-conductor cable, called NMD1, continued to be installed until the mid-1960s.

In the 1960s applications for electricity expanded, with new devices being developed that required ground protection for safe operation. These items included power

3-prong outlet on ungrounded cable

tools and plug-in electric heaters. In 1966 the Canadian Electrical Code required that all receptacles be of grounded 3-prong type.

Unfortunately many homeowners, for simply decorative reasons or providing power to their 3-prong electrical appliances, swapped their existing 2-prong, knob-and-tube fed receptacles with the modern 3-prong receptacles, without also providing the necessary ground protection. This "retrofit" is hazardous, as it provides an opportunity to plug-in equipment requiring ground protection, when in fact there is none.

Fortunately there is a simple and cost effective solution to providing ground protection to knob-and-tube fed receptacles, providing the rest of the electrical system has not been tampered with: **The Ground Fault Circuit Interrupter (GFCI).** GFCIs provide excellent ground protection to receptacles where a grounding-means does not exist. Compared to knob-and-tube replacement the installation of GFCIs is easy to do. The GFCIs can be installed locally or at the panel. GFCIs provide a safe and inexpensive solution for ground protection of ungrounded (knob-and-tube) circuits.

Aluminum Wiring

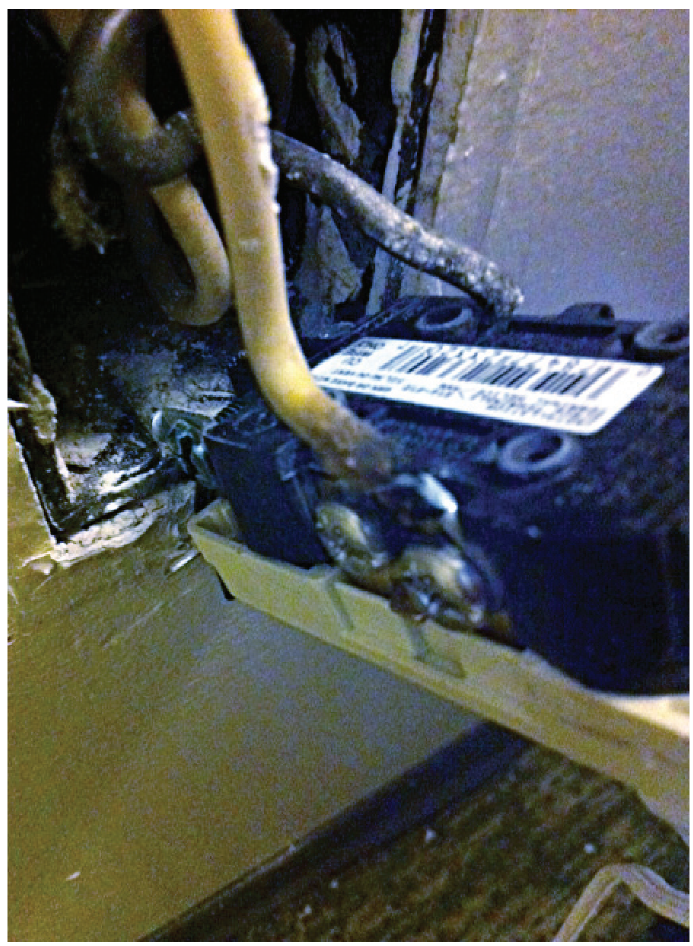
"In 1974, the CPSC determined that hazards associated with aluminum wire systems" were "unreasonable risk(s) of injury or death" and filed suit charging two dozen aluminum wire manufacturers. The CPSC indicates that homes wired with aluminum wiring manufactured before 1972 (old technology aluminum wire) are 55 times more likely to sustain connections that reach Fire Hazard Conditions in contrast to homes with copper wiring. (from Electrical Safety Foundation International, "Aging Residential Wiring Issues", 2005)

History:

Aluminum wiring was used nationwide between 1966 and 1974 in the wiring of new buildings. Dates coincide with the Vietnam War, due to an escalation in the price of copper during that period. Aluminum wiring is still widely used today for larger commercial and industrial feeders. Electrical distribution companies use it widely throughout their distribution systems including the supply service cable to most residences.

Poor quality aluminum connections can create fire:

During normal loading, electrical circuits heat up and cool down. In response to thermal cycling, aluminum expands and contracts at three times the rate of copper. Every time a circuit is used, the aluminum connections expand and contract ever-so-slightly; eventually creating a gap that exposes the wire to air. In contact with copper wire or brass screws of a receptacle for example, aluminum oxide is formed at the connection



Aluminum wire on copper outlet

point. Aluminum oxide is a poor electrical conductor and will heat under an electrical load. This creates a snowballing effect, escalating the heat generated and the further formation of aluminum oxide. Eventually, with the combination of the heat combined with the loose connection a spark can occur which can start a fire.

To assure the safety of aluminum wiring, the system must be checked by a qualified electrician knowledgeable in aluminum wiring installation and testing. Each circuit must be examined to ensure that all connections are correct and sound.

Can a building with aluminum wiring be safe? Aluminum wire itself is safe. If proper connections and terminations are made without damaging the wire and using approved materials installed in accordance with the Canadian Electrical Code there should be no safety concerns with the aluminum wiring installation. However periodic checks to assure that the connections have remained sound are highly recommended.

Conclusion

Electrical systems in buildings are complex. To draw assumptions of risk based on limited data, such as presence or not of "knob-and-tube" or aluminum wiring will likely result in inaccurate assumptions. Determining if and where there are electrical risks requires experience in electrical testing and a thorough knowledge of the electrical code.

The best assumption for determination of risk is to base the risk on the age of the building. Risk typically increases with age; the older the wiring, the greater the probability of increased risk. Assuming buildings greater than 35 years of age to be at high risk until proven otherwise is an ideal benchmark.

An impartial, third-party assessment by a qualified electrical professional interested solely in the correct evaluation of the electrical system is the best way to identify the hazards. Using this approach will allow costs to be targeted towards necessary repair of the risks rather than unnecessary, expensive replacements.

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About the Author and PowerCheck:

Brian Cook is the founder of PowerCheck Electrical Safety Services Inc. He is a BC Trade Qualified electrician and an Electrical Field Safety Representative, class B (a designation issued by BC Safety Authority).

PowerCheck specializes in conducting electrical safety assessments of older residential and commercial buildings for the insurance industry. PowerCheck currently conducts electrical safety assessments in all major centers throughout Western Canada. For further information on PowerCheck go to: www.powercheck.ca