Electrical Safety

When most of us think of the dangers of electricity, the first thought that comes to mind is the hazard of electrocution. In reality, your chances of being electrocuted in your home are pretty low; only about 200 such deaths occur from electrocution each year in this country. Technological advances, specifically GFCIs, are one of the reasons for fewer electrocutions in recent years. Statistically, the gravest danger posed by electricity in the home is **fire**. Over 51,000 residential electrical fires occur each year, resulting in over $700 million in property damage. Nearly 400 people a year die from residential electrical fires, and there are thousands of injuries. Electrical issues are the most frequent items of concern in my inspection reports.

Older Homes

Early wiring systems were ungrounded, with 110-volt electrical circuits that had only two wires, outlets for two-prong plugs, and often with only 60-amp service. Insurance companies and loan vendors typically now require homes to have 100-amp service as a minimum. After 1965 residential electrical systems were required to be grounded at the service entrance, and a third, grounded wire was added. The transition did not necessarily take place overnight, or smoothly, and even today we find a large number of homes with ungrounded, partially or improperly grounded electrical systems. Existing homes are typically not required to upgrade, though most jurisdictions have requirements for a permit and upgrades when a contractor performs significant remodeling. We generally suggest that wherever possible, at least important circuits such as kitchens and bathrooms be upgraded to grounded wiring whenever possible.

Old Wiring

Early wiring was thinly insulated with fabric and separated by an air space ("knob & tube"). *One specific danger with knob & tube wiring is covering it with insulation in an attic; this can cause it to overheat and create fires.* Some versions of early wiring had rubber-like insulation wrapping that will dry and break down with age.

Older wiring systems were not designed to handle large loads. The most dangerous concern is new circuits that have been added onto the original wiring, uncovered and overstuffed junction boxes, and open splices or junction boxes in hidden wall spaces. This is where the electrical fires often start.

Old Panels

Many homes still have older panels and may have not experienced a problem. However, old breakers do not improve with age. Like any other mechanical device, breakers and wiring become more unreliable over time. Another complication is the difficultly adding or replacing breakers in old panels due to lack of availability and high prices. In many cases, homeowners should consider replacing old panels based solely on out-of-date design and age. Electricians generally recommend that panels and fuse boxes older than 50 years should be considered to be at end of reliable service.

Some brands of panels and breakers were subject to failure to properly shut off power in case of overload, overheating or shorting. Though investigated but never specifically recalled, *Federal Pacific Stab Lok*

(FPE) and *Zinsco* panels are considered by many experts to be potentially dangerous due to a poor proprietary bus design and/or poor quality control (especially the older versions). Some breakers did not trip when they should have, and many have been known to come loose inside the panel causing arcing and creating a fire hazard. Due to their history of failure, electrical panels from these manufactures in particular should be reviewed by an electrician to determine if they are safe and reliable.

Aluminum Wiring

Though not found very often, aluminum wiring is a significant concern. Between 1965 and 1973 when there was a shortage of copper, single strand aluminum alloy 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. A good discussion is available at inspectapedia.com.

Aluminum wiring, when properly installed, can be just as safe as copper. For example, most main service wires between the meter and the panel are *stranded* aluminum wires. But if the older ***single-strand*** wiring for outlets and lights has not been properly installed and maintained, poor connections can present a fire hazard where the wires attach to breakers, outlets, and switches. Because of its greater tendency of aluminum wiring to expand and contract with heat (current), it is important that the correct amount of torque be maintained at the connections to the breaker terminals in the electrical panel, and at connections to devices. Early breakers that were not designed for aluminum alloy wiring should be replaced. If light fixtures and receptacles are not designed for aluminum (most are not), then special copper "pig tails" should be installed as a wiring bridge between the aluminum conductors and the device connections. Frequently used outlets in bathrooms and kitchen should be checked carefully for scorched wires.

Most Frequent Source of Problems

In general, old or new, our experience has been that **most problems are a result of improper and unsafe modifications** and additions to existing wiring systems.

Most common electrical code violations as reported by electricians:

Most of these are electrical fire hazards

1. Overloaded circuits.
2. Improper use of wire types:
   - Using NM cable in conduit, or using it underground or outdoors;
   - extension cords run underground;
   - substitution with extension cords when fixed wiring is needed
   - substitution with single strand wiring (NM cable) when flexible cords are needed
3. Improper size of wire or breaker; undersized gauge of the electrical wire limits how much current (amps) the wire can safely carry without overheating
4. Several issues are related to junction boxes:
   - Too many wires coming into a junction box, overcrowded boxes
   - Insufficient wire slack (each wire should be 6" long)
   - Inaccessible junction boxes and boxes hidden inside walls
   - Metal junction boxes that are not grounded
5. Over-stripped insulation at connections to breakers or fixtures (too much bare wire showing)
6. Unsafe splices (twisted wires, splices held together

with electrical tape, too many conductors under one wire nut)

7. Tapping into circuits that should be dedicated
8. Install new fixtures directly onto old wiring. Newer light fixtures are rated for higher temperatures (resistance) than old wiring is capable of carrying
9. Combining dimmer switches and normal switches in one box (dimmers tend to heat up)
10. Improperly secured wires (or not secured at all); unprotected wiring (i.e. at water heaters)
11. Holes for wiring in framing studs drilled too close to the edge (need at least 1-1/4 inches of wood); missing nail plates. Unprotected wiring inside walls can be damaged when nailing drywall or hanging pictures. Improper stapling of wires to stud framing.
12. Overcrowded wiring in panels, or too many wires bundled together when passing through holes in the panel or holes in studs and through walls (can create overheating)
13. Reversed polarity (hot and neutral wires reversed) is extremely common when wired by non-professionals
14. Ungrounded three-prong receptacles; boot legging grounds from the neutral in an ungrounded 3-prong receptacle, unsafe grounding to metal pipes
15. Loose connections in electrical panels, at receptacles and fixtures
16. Only running 3 conductors to a sub panel when a dedicated ground is needed (i.e. when upgrading the service panel while leaving the old panel in place as a sub panel, and not updating service feeds and grounding to the old main panel). Ungrounded panels in detached buildings.

"Double-taps" (two or more wires connected to the same breaker terminal designed for only one circuit) is very common, and usually called out by home inspectors because it is easy to spot. In most cases electricians do not find these to be a significant threat unless it is two different wire sizes. However, multiple double-taps in the same panel can indicate too many circuits have been carelessly added; in that case we suggest addition of dedicated breakers for the added circuits. If the panel is too small for the additions, then a new larger panel or a sub panel should be considered.

Proper grounding and bonding play important roles in other parts of the house as well. Water pipes, gas lines, phone or TV circuits, other metal objects may also carry unwanted electrical charges if not properly bonded to the grounding system

Improvements in Electrical Safety

GFCI

You often see these as the special electrical receptacles in bathrooms or kitchens that have "Test" and "Reset" buttons. New ones also have a small LED light that indicate when the power has been cut. These are **Ground-Fault-Circuit-Interrupters**, (GFCI's or GFI's). Their purpose is to protect people from electrocution due to **ground faults**.

Ground faults occur when current leaks from a circuit or device, and a person's body provides a path to ground for this current. This transient current in the ground wire or metal casing can be caused by contact between the hot and ground wires (or its metal case) in a failing electrical tool or appliance, or water providing a ground connection between the hot wire and a person. The person can be injured, burned, severely shocked, or electrocuted. GFCI protection does *not* prevent overloads on the circuit. That is the job of a circuit breaker at the main panel where proper wire sizing, grounding and bonding are important.

GFCI Location

Beginning in 1975 the NEC began requiring installation of GFCI protected circuits for bathrooms and exterior outlets. Early adoption of this was accomplished by use of a GFCI breaker at the main electrical panel. Requirements were expanded through the years, with kitchens, basements, and whirlpools being added in 1987. Currently GFCI protection must be provided for 15 and 20-amp 120-volt circuits in bathrooms, all outlets serving counters in the kitchen, garages, crawl spaces, unfinished basements, wet bar sinks, near laundry tubs, and outdoor outlets.

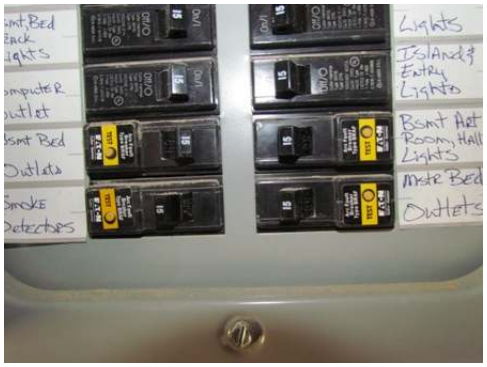
GFCI Upgrades

The addition of GFCI protection is frequently recommended because it is an extremely affordable, quick and easy safety improvement.

GFCI circuits protect you, even in homes with ungrounded wiring

GFCI outlets also work on ungrounded systems; though GFCI is not a substitute for grounding in older homes with ungrounded electrical systems, upgrading outlets to GFCI should always be done for added protection. Just be aware that GFCI is not a viable upgrade for some multi-wire branch circuits that are occasionally present in some panels.

AFCI: New Devices Prevent Electrical Fires



These devices provide enhanced protection from fires resulting from arc faults caused by damaged or unsafe wiring conditions. The U.S. Consumer Product Safety Commission (CPSC) estimates that AFCIs could prevent more than 50 percent of the electrical fires that occur every year. Beginning in January 2002, the NEC requires Arc-Fault Circuit-Interrupters (AFCI's) for bedroom circuits in new residential construction. Requirements were changed in 2008 to include all habitable rooms of the home.

An electrical arc is a spark, like the spark plug in our cars. Electrical arcs can create temperatures in excess of 5,000^{o} C, hotter than the surface of the sun. Home electrical fires are caused by arcing from old aluminum wiring, bad electrical connections at poorly installed switches or outlets, wiring damaged by nails through the walls (i.e. when hanging pictures), frayed extension cords caught in doors or under furniture, furniture pushed against plugs in an outlet, natural aging, and cord exposure to heat vents and sunlight. An ordinary circuit breaker does not shut off the flow of current unless the arc draws enough current to resemble a direct short. In many cases, the circuit breaker thinks the arc is just another electrical load, and allows the current to continue. AFCI's are intelligent at detecting the pattern of an improper arc, and instantly shut off power to that circuit.

Similar to GFCI's, AFCI circuit protectors can also be installed in homes with ungrounded wiring, and makes good sense in cases of old and questionable wiring (though is not a substitute for careful review and new re-wiring where needed). Cost for AFCI breakers is a bit higher than the simpler GFCI upgrades, and again these do not work on the occasionally seen multi-wire circuits.

The only type of AFCI circuit protection device commonly seen is the breaker type, though receptacle type devices are becoming available. AFCI breakers at the electrical panel combine conventional circuit breaker functions for traditional overload and short-circuit protection with arc fault protection. AFCI circuit breakers (AFCIs) have a test button and look similar to ground fault circuit interrupter (GFCI) circuit breakers and should be tested on a monthly basis like GFCI breakers and outlets.