Newsletter Article

How safe is "This Old House's" Wiring?

According to the National Fire Protection Association (NFPA), there is an annual average of 24,200 home fires attributed to electrical distribution systems or lighting equipment, causing 830 injuries, 320 deaths and $700 million in property damage.[1] A study conducted by the U.S. Consumer Product Safety Commission (CPSC) in 1987 indicated that the frequency of fires in residential electrical systems was disproportionately high in homes more than 40 years old.[2]

The disproportionately high incidence of fire in the electrical systems of older homes can usually be attributed to one or more of the following factors:[3]

- Inadequate and overburdened electrical systems.
- Thermally reinsulated walls and ceilings burying wiring.
- Defeated or compromised overcurrent protection.
- Misuse of extension cords and makeshift circuit extensions.
- Worn-out wiring devices not being replaced.
- Poorly done electrical repairs.
- Socioeconomic considerations resulting in unsafe installations.

Although residential electrification first began in the later part of the 19th century in the more wealthy homes, by the beginning of the 20th century, electricity in the home was becoming available and more affordable to many people, especially those living in the urban areas. With over 100 years of residential electrification in many cities and towns, the aging of the residential electrical infrastructure is beginning to raise concerns within the electrical and firefighting communities. Besides the natural effects that age can have on wire insulation and electrical equipment over time, residential electrical systems are seldom inspected after their original installation. In addition, the quality of the original installation may be a factor, as well as inappropriate upgrades or additions that may have been done by unqualified homeowners or others throughout the years.

This report describes a research project to characterize the condition of various age groups of residential electrical components by surveying, recovering, and analyzing representative samples of actual installed residential wiring systems, wiring devices, and similar distribution and utilization equipment. The data and analysis of this equipment is intended to provide critical information to code writers, especially for NFPA 73 Electrical Inspection Code for Existing Dwellings, and the National Electrical Code® (NEC®), as well as AHJs, electrical equipment manufacturers, testing laboratories, installers, property owners, and insurers.

12.0 Summary of Findings

Electricity has been a permanent feature in residential occupancies for over 100 years, and it was known to be a cause of fires since the earliest days of its use. Recent studies have shown that the frequency of fires in residential electrical systems is disproportionately higher in older homes. Three factors that could influence most the likelihood of a residential electrical fire are; 1) the effects of natural aging over time on the electrical system wiring and equipment, 2) misuse or abuse of the electrical system components in the home by the occupants, and 3) non-*Code* compliant installations, upgrades, or repairs.

Some of the houses may have reached their structural end-of-life before they were demolished, and for economic or other reasons, the last inhabitants of the

house may not have adequately taken care of the electrical, mechanical, or plumbing aspects of the building. This appeared to be the case for houses AL-5, AL-9, MA-1, NY-1, NY-2, OR-1, and WI-1. The reader is cautioned about drawing conclusions about houses in general, especially when based on data from houses that may have been neglected and not adequately maintained by the owner or occupants prior to its demolition.

12.1 Effects of Aging

Although many homes have had their electrical system upgraded or expanded over the years, many also have not. The electrical wiring within the home may be the most vulnerable to aging, as it is often buried in walls or ceilings, or installed in attics or crawl spaces that are often not used. In addition, these nonclimate controlled areas, like attics and crawl spaces, can be subjected to extreme temperature conditions and changes, as well as dampness and moisture. All of these factors can contribute to, or even accelerate, the effects of aging.

Residential wire installations before the 1950s traditionally used conductors with thermoset rubber insulation. These were found to still be performing well in many residential environments and expected use conditions. However, older rubber compounds are known to become brittle with age, which can be a potential hazard when these wires are subjected to bending, abrasion, or harsh usage over the years. Testing of older rubber wire samples from the houses demonstrated this fact. However, the thermoplastic insulated wires typical of the 1950s and later continue to perform with excellent results under most all conditions, even after many years of service in the home.

Older armored cable installed before the 1960s may not have a bonding strip (e.g., bare aluminum conductor) installed between the metal armor and the current carrying conductors to help supplement the use of the armor as an effective grounding path. Older examples of this cable that were found without this bonding strip exhibited armor resistances that in some cases were more than double the original design value.

Residential overcurrent devices, which consisted mostly of fuses before the 1950s and circuit breakers after the 1950s, continue to perform as expected, unless they have been subjected to abuse or misuse. If properly installed and maintained, these overcurrent devices continue to provide protection to the wires and cables installed on the residential circuits.

Receptacle outlets can be still found original to houses as far back as the 1920s, and possibly even earlier. The recovered receptacles did show some decrease in performance with age, however, it is often not known the extent of abuse or misuse these receptacles may have been subjected to over time, as they are part of the wiring system that is routinely interactive with the user through the use of cord- and plug-connected devices. As such, the effects of aging (or abuse), which may include broken faces, loose plug blade retention, hot plugs, etc., are often easily detected by the user. When such receptacles are found, they should be replaced.

Other electrical system components, such as luminaires, do not appear to be affected as much by age as they are by misuse or mis-installation. If properly wired and lamped, luminaires can show good performance over long periods of

time.
GFCIs, an important safety device for protecting the occupants of the home from accidental electric shock, can be prone to failure with age because of the inherent electronic components. However, GFCIs are provided with an integral test feature to provide the user with a convenient means to periodically test the device for its proper functionally. Non-operational GFCIs found in this study and others, may be an indication of the need for more consumer education in this regard, or possibly the need for future technology devices that can perform a built-in test function.

12.2 Misuse and Abuse

Many aspects of the residential electrical system can be the subject of misuse or abuse by the homeowner or occupant. This can include; 1) poorly done electrical repairs by unqualified homeowners, 2) defeated or compromised overcurrent protection, 3) misuse of extension cords or makeshift circuit extensions, and 4) socioeconomic considerations resulting in unsafe conditions, such as worn-out electrical devices not being replaced.
Several houses were found with extension cords used on a permanent basis, usually because of the lack of sufficient receptacle outlets typical of older houses. Some examples were also found of devices intended for permanent wiring actually wired with a makeshift extension cord or other type of flexible cord. These would appear to be installations or repairs typical of unqualified homeowners.
Most houses that were found with plug fuses for protection of the branch circuit wiring were also found with 30 Amp fuses protecting No. 14 or 12 AWG copper wire. No houses were found with tamper resistant Type S fuses. However, in most cases older plug fuse panels were not marked with a maximum fuse size rating for the particular circuit involved. One house also exhibited two examples of a penny bridging a blown plug fuse.
Overloading or abruptly pulling plugs from a receptacle could cause damage to the outlet device. Furniture or other objects striking the face of the receptacle could also be a source of damage over time. Since the receptacles were recovered from unoccupied houses, it was difficult to determine the extent that abuse or misuse may have played in the overall condition of the receptacle.
Many examples were found of luminaires being overlamped. Most luminaires are clearly marked with a cautionary marking indicating the maximum wattage rating and type designation for the lamp or lamps to be installed.

12.3 Non-*Code* Compliant Installations

Non-*Code* compliant installations can be the result of several factors, including; 1) lack of local laws requiring building permits and *Code* inspection at time of original construction or remodel, 2) professional installers not understanding or complying with *Code* requirements that were current at the time, and 3) unqualified homeowners performing their own electrical work. Without proper building permits and *Code* enforcement through qualified electrical inspections, these non-compliant installations can result in unsafe wiring practices. The potential hazards associated with a non-*Code* compliant installation may go undetected for many years, only to someday result in a house fire or an electric

shock to an unsuspecting future occupant.

Most of the hazardous conditions that were found in the 30 houses could be attributed to a specific *Code* requirement not being complied with. Over 25 different *Code* violations were found in at least one, and in most cases several, of the houses. Although some of the *Code* violations could result in hazards that were more potentially dangerous than others, all involved some degree of risk to the occupant.

Many of the *Code* violations involved the fixed wiring within the house. These violations included non-compliant wiring practices such as installing multiple wires in a single terminal, making improper splice connections, not using appropriate cables, raceways, or outlet boxes (open splices), not properly supporting wires and cables as they are installed in wall spaces or fixed to boxes, using cable intended for indoor use outdoors, and using flexible cord or cable as a substitute for fixed wiring. The CPSC estimates that there are 6,400 annual fires resulting in 30 deaths, 150 injuries, and $165 million in property loss from fires involving the installed wiring in the house. [8]

Several houses were found with *Code* violations originating at or near the entrance of the electrical service. These included using the wrong circuit breakers for the panelboard involved, not using circuit breakers of the proper ampacity to protect the installed wiring, and installing equipment outdoors that was intended for indoor use. The CPSC estimates that there are 1,400 annual fires resulting in less than 10 deaths, 20 injuries, and $132 million in property loss from fires involving devices at the electrical service entrance of the house. [9]

Code violations involving luminaires included not following manufacturers instructions for the proper rating of the supply conductors, and improperly installing recessed luminaires against building materials and thermal insulation. The CPSC estimates that there are 2,300 annual fires resulting in 10 deaths, 70 injuries, and $45 million in property loss from fires involving installed luminaires. [10]

Many of the *Code* violations involved the potential for electric shock for a person coming in contact with the electrical system of the house, and the risk of an accidental electrocution. These violations included not properly identifying grounded, ungrounded, and grounding conductors, not properly grounding or bonding equipment, using grounding type receptacles on circuits without an appropriate equipment ground path, and installing receptacles outdoors in a manner intended for indoor use. The CPSC estimates that there are about 50 accidental electrocutions annually involving residential wiring, panelboards, circuit breakers, and outlets. Another 40 electrocutions involve household appliances connected to the wiring of the house. [11]

[8] Read full Report at www.nfpa.org/assets/files/PDF/Research/RESAReport.pdf