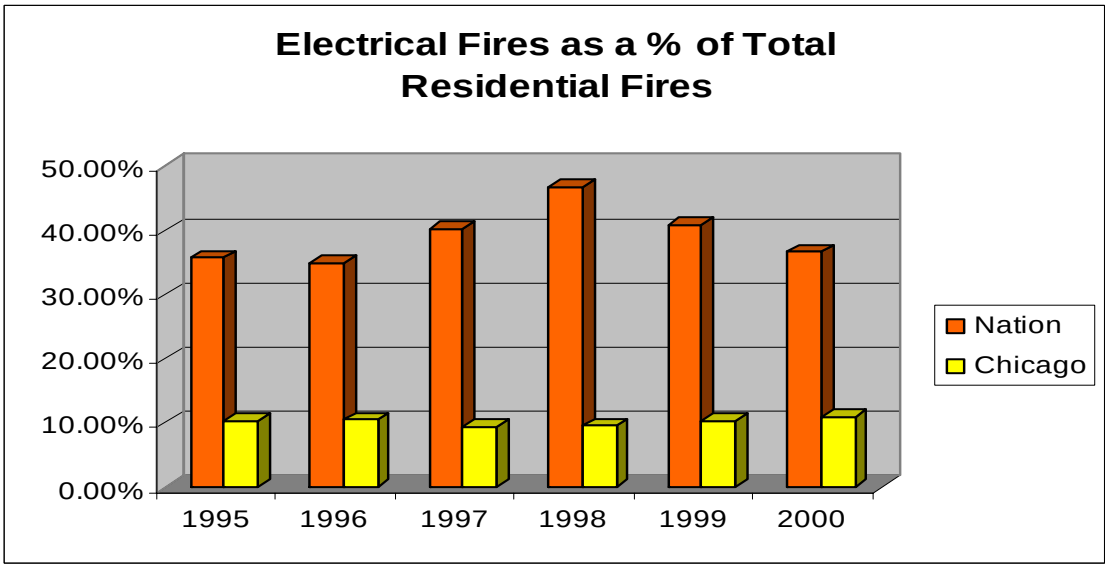
Presented by Timothy Arendt 10/18/2006

Fire Safety Options in Design and Code Practices to Minimize Fire Problems Due to Aged Electrical Wiring Systems.

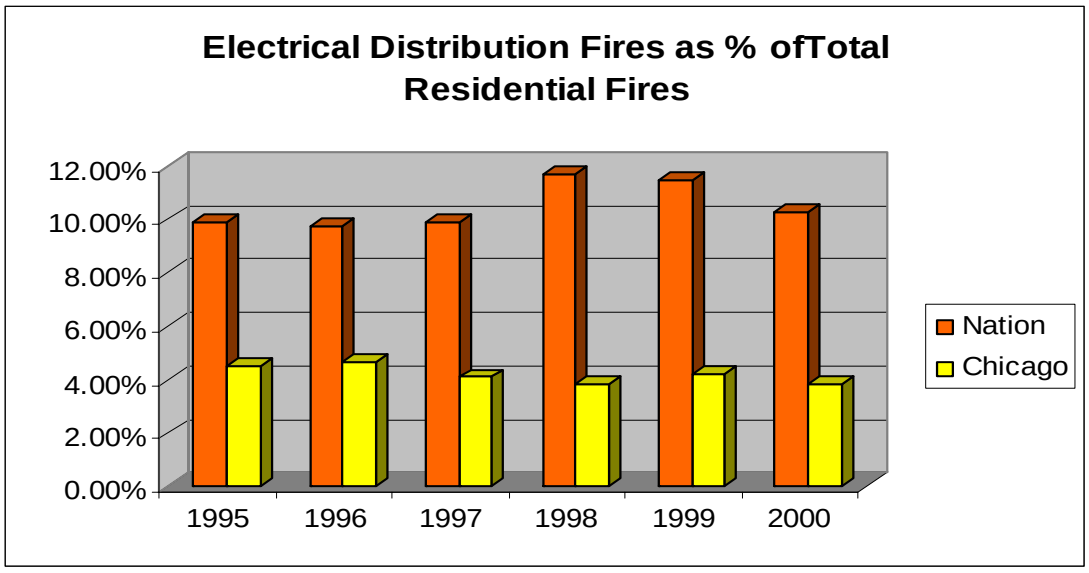
Chicago is an interesting location for a symposium on residential fires and aging electrical wiring. We certainly have a spectacular fire history. It dates back to pre-electric lighting – the kerosene lantern sitting on the bale of hay, kicked over by Mrs. O'Leary's cow. Throughout this history we have learned valuable lessons such as: After the Great Chicago Fire of 1871, where nearly all of the housing stock was consumed, we learned that keeping an ignition source away from a fuel load is good practice and that we needed building codes to prevent similar occurrences in the future. After the Iroquois Theater fire of 1903, where 600 people lost their lives in 15 minutes, we learned that heat producing ignition sources (carbon arc spotlights) need to kept away from combustible stage scenery, curtains and materials. After the McCormick Place fire of 1967, where one of the countries largest convention centers was completely destroyed, we learned of the potential hazards associated with temporary, open show wiring used in close proximity to combustible materials. Recently at a downtown high-rise fire at LaSalle Bank, we witnessed the value of metal raceway in maintaining the survivability of lighting circuits and building life safety systems. On television we watched firemen battle the blaze for hours while illumination continued to remain lit. With these and other lessons from the past, Chicago developed a modified version of the National Electrical Code. Some would say that it is more stringent, I would say that it is safer.

The net result is that Chicago has nearly 4 times fewer residential electrical fires than found nationally.



Source of Data: CPSC Residential Fire Loss Estimates and Chicago Fire Department NIFRS

In addition, statistics show that, residential electrical fires caused by electrical distribution, which includes the installed wiring is dramatically less in Chicago than can be found nationally.



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What does Chicago do differently that accounts for maintaining a safer environment for its citizens from residential electrical fires?

This year marks my 40th year as an IBEW electrician. Twenty-five of these years have been spent with the City of Chicago Building Department as inspector, supervisor and the last seven years as Chief Electrical Inspector. I am retired from the City but, during the later part of my career, I chaired the group responsible for updating the Chicago Electrical Code to closely mirror the NEC. I became intrigued by the National Fire Protection Research Foundation (NFPRF) Electrical System Aging Project after reading about it in the IAEI News. The harvesting of samples from around the country for the purpose of researching possible causes for residential fires is a positive step toward understanding the nature and cause of such fires. I am a voting member of UL STP 1699 Arc-Fault Circuit Interrupters, and I know the value of technology in reducing fires caused by electrical arc-faults. I believe that many of the published problems associated with aging wiring aren't an issue in Chicago – and the municipalities that have adopted similar codes. These problems have been mitigated by the long-standing requirement for metallic raceways, even in residential applications. Some people find it amazing that Chicago maintains this strong requirement. Frankly, I am proud of the part I have been able to play in the development and maintenance of this Code. It has played a great part not only in electrical and fire safety for the people of Chicago, but has also provided convenience and economical solutions as our use of electricity and need for additional circuitry has grown.

My presentation is not an attempt to disparage any particular wiring method nor to maintain that it is *only* the wiring method that impacts the problem of aging wiring. It is

an attempt to look at this issue from a different perspective and to encourage a discussion about wiring *options* as well as various code proposals that have been submitted to the NEC in an attempt to help "solve" the problem of aging wiring in our homes – specifically proposals relating to Arc Fault Circuit Interrupters.

In the November-December 2005 issue of the IAEI News, Kathleen Almand of NFPRF, explains the *Aging Wiring Project* tasks and goals. Kathleen asks the question, "Why is there a residential electrical fire problem in the United States, even though we have such a good code?" This question begs my answer and is the reason for my requesting to address this group and to be part of this important record.

In Article 90 of the NEC we know that the purpose of the Code "…is the practical safeguarding of persons and property from the hazards arising from the use of electricity." The use of the word "practical" implies that there are several wiring methods or ways to accomplish acceptable electrical installations. Where there are several acceptable methods, there will always be a hierarchy of methods that balances safety and economic interests.
The NEC recognizes 13 or so acceptable wiring methods for concealed residential wiring. These include metallic and non-metallic raceway and cable methods. Just as all methods are not equal in cost, all methods are not equal in safety. There exists an inherent hierarchy that balances safety and cost.

To reach my understanding of this hierarchy, the following facts are taken into consideration:

1. Energized electrical conductors are an ignition source for fires. (ex. The arcing characteristics of ground faults and short-circuits.)
2. Conductor insulation, cable jacket material, and wooden building framing materials are combustible and provide an easily ignitable fuel load for residential fires.
3. Separating the ignition source from the fuel load is a proven viable method for reducing fires. (Lesson learned from the Great Chicago Fire)

Based upon my experience, if I were to construct a list of the 13 wiring methods permitted in the National Electrical Code (NEC), the methods that separate the ignition source from the fuel load would top the list and in my opinion be the safest.

Nationally the residential wiring method used in the overwhelming majority of dwelling type occupancies for the past 60 years is a method that has the ignition source and the fuel load in very close proximity. Recent Code direction has been to expand the use of this method of wiring. In Chicago, Cook County and the major portion of northeastern Illinois for the same period of time, metal raceway has been used exclusively in 100% of the legally constructed dwelling type occupancies. This includes one and two family, multifamily, affordable housing, mid-income and high-income type dwellings. The Chicago area offers itself as a microcosm for studying the potential increased safety level of residential wiring that is based exclusively upon the proven method of isolating the ignition source from the fuel load with a non-combustible metal barrier (steel raceway).

As shown by the graphs earlier, residential electrical fires in Chicago are substantially less than the numbers found nationally. The only difference is the metallic raceway wiring method used.

James Lardear in a 2004 *necdigest* article *"In the real world, not everything gets better with age"*, discusses the issue of aging wiring and quotes Mr. William King of CPSC in identifying the "Top 3 residential wiring safety issues."

1. **Degradation of insulation and conductor over time.** "Heat, light and temperature affect insulating materials....." "When working with older wiring it is many times better to replace wiring that is being disturbed than to risk cracking brittle insulation." "Some electricians use a rule of thumb that says 30-year-old wiring should be replaced since it is difficult to predict how badly it may age."
2. **Heavier load today than when older buildings were originally wired.** Additional appliances, outlets and lighting in use today can stress the wiring of yesterday.
3. **Electrical work installed or modified by untrained persons.** "Do-it-yourselfers and less than skilled electricians can create serious code violations to the point where a lot of the work results in an accident waiting to happen." Add to this the mechanical damage to wiring done originally by qualified persons or even by rodents over time. Bundled cables, carelessly driven staples and tight cable bends contribute to mechanical stresses that are often overlooked as walls are closed up.

Along with understanding the fact that there are fewer residential electrical fires in Chicago, consider how the use of metal raceway has mitigated each of the 3 causes above:

1. Consider the overheated, brittle, conductors at a 60 year old ceiling fixture. As explained above, the best course of action would be to replace the wiring in its entirety. This job may entail chopping out or other damage to the wall and ceiling surfaces to accomplish the task. More often than not the course of action would be to carefully apply some heat shrink or tape to bare conductors then shove everything back in the box and say a prayer. Unfortunately, this condition is likely to eventually become a fire loss statistic. In Chicago, very often the course of action would be to pull out the existing brittle RH or TW conductors back to the panel or some point where there is no evidence of conductor degradation. (See photos). The 1946 generation 60 year old wiring becomes 2006 generation wiring simply because of the ease with which the conductors can be replaced within the metal raceway. There is no damage to walls or ceiling surfaces. Consequently much of the aged wiring that is causing havoc around the country has been or is replaced in Chicago as it is discovered. Another plus of easily replacing aged wiring is that new devices, and new panel board, are often installed at the same time the aged conductors are replaced. **The result is fewer fires from degraded conductor insulation and an improvement in the entire electrical distribution system.**

2. Dwelling type occupancies wired in the 1970s and early 1980's with aluminum branch circuit conductors have simply been re-wired by pulling new copper conductors in the existing raceways. No damage to or replacement of drywall was required. A typical 2 bedroom condominium would take 2 men 4 hours to re-wire and re-device. **Result is fewer fires from degraded conductor insulation**.
3. Throughout the life of a residential building, new loads are often added. Additional kitchen circuits, dedicated microwave circuit, dishwashers, ceiling fans, and air conditioners are typical new loads added to existing systems. In Chicago, very often additional wiring can be pulled through existing raceways. Where there is (one) small appliance circuit originally installed in a kitchen, a second can easily be added using the existing raceway with no damage to existing walls. Multiple home computers, laser printers, A/V amplifiers, video recorders are all part of today's world. When faced with overloaded circuits a homeowner may just substitute higher rated overcurrent protection when no raceway is available to add circuits. **Result is more fires from overloaded or possibly over fused branch circuits.**
4. Metal raceway wiring methods are less likely to be tampered with by untrained persons. The installation of metal raceway with bends and kicks and offsets can be a daunting challenge for a homeowner. Just as with other wiring methods, tampering can produce hazardous safety concerns. In Chicago homeowners are prevented by ordinance from performing electrical installations or modifications to existing systems. Steel raceway provides an increased level of mechanical protection for electrical conductors. Consider the AFCI test in UL Standard 1699: A guillotine arm with a razor blade is slowly closed on energized NM Cable to initiate an arc. A similar test with conductors enclosed in metal raceway would produce broken razor blades. Rodent damage by mice and squirrels is often brought up as an issue with residential wiring around the country. In Chicago rodents prone to chewing on conductor insulation enclosed in steel raceway would most likely result in broken teeth. **Result is less damage and fewer fires.**

Metal raceway is a viable method for reducing residential fires and for minimizing the negative effects from aged conductors and wiring. In my opinion this method is the most "practical" in being consistent with the purpose of the Code as described in Article 90. The material cost, labor hours and skill needed for installation do not appreciably increase the cost of dwellings when compared to the increased safety payback in reduced fires. Housing in Chicago does not cost more than other large cities that use wiring methods that I would consider less safe. Housing in suburban areas of Cook, DuPage, and Lake Counties do not cost more than housing in comparable areas of the country. People that live in affordable housing in these areas are entitled to and are mandated to receive the same level of increased safety as upper income dwelling occupants.

Over the last several code cycles there has been much debate concerning the value and use of AFCIs in reducing residential electrical fires. Any technology that has the result of reducing these fires is worthwhile in my opinion. It is my belief that mandating the use and type of AFCIs should be looked at in terms of the wiring methods used in a particular occupancy. For instance, would AFCIs serve any purpose in protecting concealed branch

circuit wiring if the method used was MI Cable? Likewise, would there be value for AFCIs if RMC, IMC, or EMT were used as wiring methods concealed within the walls of dwellings? Certainly AFCI technology would be very desirable for device glowing contacts and other series or parallel arcs that develop in cords and appliances served by these branch circuits. The assumption for AFCI technology, in general, is that all residential branch circuits are wired with a method other than metal raceway.

NEC CMP-2 for 2008 has accepted a proposal to require AFCI protection for all 120 Volt 15 and 20 Amp circuits in a dwelling. The data presented shows the benefit of steel raceway in substantially reducing residential fires. I suggest and have submitted a comment that an exception would be appropriate action where steel raceway is the wiring method used for residential branch circuits. Further development and availability of outlet type or combination type AFCIs could be used to protect extensions of the branch circuit that have less physical protection. Requiring AFCI protection where steel raceway is used, as a choice, will have a stifling effect on the use of a wiring method that has a demonstrated ability for reducing electrical fires. If it becomes less practical to use steel raceway, we would also lose the benefit of being able to easily replace the aged wiring of the future.

In conclusion, I would like to answer Kathleen Almand's question. We have a residential fire problem because the Code allows many wiring methods and the method chosen in the marketplace is driven primarily by cost. The Code outlines minimum requirements. If in the marketplace the least safe methods are used based upon perceived cost realities, there will always be a negative affect upon residential electrical fires. When one considers the cost of branch circuit AFCI protection plus the need for a separate equipment grounding conductor in other wiring methods, these perceived cost realities have to change. Each of these wiring methods has both safety and economic implications that impact residential fires and the consequences of these fires. There exists an entire technology, AFCI with its own Standard UL 1699, to reduce the inherent limitations of the less safe methods allowed by the Code. In my opinion AFCI technology will have a great impact in reducing fires associated with non-metallic cable methods. However that protection comes with its own substantial cost. If more "practical" methods are used, such as in Chicago, the need to protect the fixed branch circuit wiring becomes less of a requirement. The lesson we learned from our Great Chicago Fire is as practical today as it was in 1871. An ignition source should be isolated from a fuel load. Non-combustible steel raceway serves that function very well and has served to protect the citizens of Chicago for over 60 years. The safety benefits are proven and real. Steel raceway should be considered a viable, practical option by users interested in reducing residential fires. Code panels, testing laboratories and knowledgeable people in the industry should be willing to recognize safer wiring methods. Lastly, insurance underwriters whose very existence depends on closely following statistical data and trends should be at the forefront in recognizing and rewarding the use of metal raceway for residential wiring.