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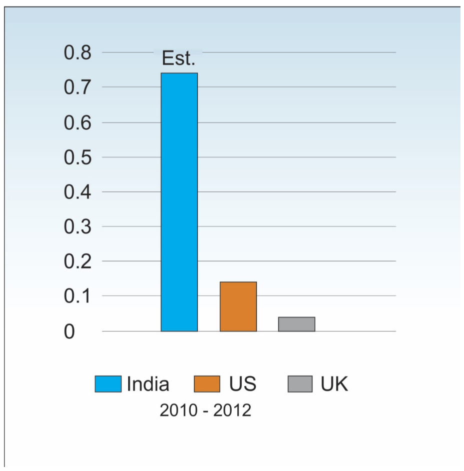
Advancing Electrical Safety

By: Arthur J. Smith, III, P.E.

SAFETY BY DESIGN

Waldemar S. Nelson's history is rich in helping develop ANSI, API, ACI, NFPA, etc. Codes and Standards. Our unique expertise and perspectives have helped enrich these codes and standards that not only improve system designs, but also save lives. NELSON was also recently recognized by the IEEE Standards Association for "outstanding contributions to the development of IEEE Standard 1584TM-2018 IEEE Guide to Performing Arc-Flash Hazard Calculations". Almost 25-years ago, long before Arc-Flash became a household word, NELSON participated in staged arc-flash testing at high-power test laboratories. This testing allowed a small group of engineers from NELSON, several large industrial companies, and a leading university to research and help document this phenomenon. The small group of engineers then used this information to not only write and present an award-winning IEEE paper "Staged Tests Increase Awareness of Arc-Flash Hazards in Electrical Equipment", but also provide several tutorials that significantly raised industry awareness and save lives from this mostly unknown hazard at the time. This was the first known attempt to stage arc-flash testing while capturing video, thermal temperatures, sound pressures, blast pressures and light. How much have these standards advanced personnel safety? For



COMPARING UK, US AND INDIA OCCUPATIONAL ELECTROCUTION FATALITY RATES

Credit: 2019 IEEE IAS ESW Tutorial Preview, "Thru Design"; Lanny Floyd, March 4, 2019

example, if we compare the occupational electrocution fatality rates of the US with its mature electrical standards and a developing country with its less mature electrical standards, we find the developing country's occupational electrocution fatality rates are approximately six-times that of the US. This makes us feel good that our standards work is having a positive impact and saving lives. However, if we do a little more digging, and compare US occupational electrocution fatality rates with those of the UK, we learn something very disturbing. US occupational electrocution fatality rates are almost six-times higher than in the UK! So why the large discrepancy in occupational electrocution fatality rates between two very advanced countries with mature Electrical Systems, Codes and Standards? If we look back to the 1980's, both countries had similar occupational electrocution fatality rates. However, in 1989 the EU Framework Directive was developed by Fred Manuele. Mr. Manuele stated "Risk assessment is the cornerstone of the European approach to prevent occupational accidents and ill health. If the risk assessment process – the start of the health and safety-management approach – is not done well or not at all, the appropriate measures are unlikely to be identified or put in place." Items like "touch safe connections" and "increased safety" became standard practice in the EU. These are not just "feel good" phrases but actual risk reduction designs, and after 30-years of not only following codes and standards, but also incorporating the assessment process, the UK was able to achieve remarkable results addressing these risks. So, what can the US do to start addressing electrical risks on a national level in the hopes of achieving similar results? The same year, 1998, that the EU Framework Directive was developed to consider risk assessment during design, NELSON presented the first Designing for Safety paper at the IEEE Electrical Safety Workshop. The 1998 paper was titled "Reducing the Electric Arc Hazard by Design" with other Designing for Safety papers, followed by many different authors at

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the IEEE Electrical Safety Workshop. What can we do to help consider risk assessment during design on a national level instead of the somewhat limited audience provided by IEEE meetings and workshops in order to have a real impact on advancing electrical safety?

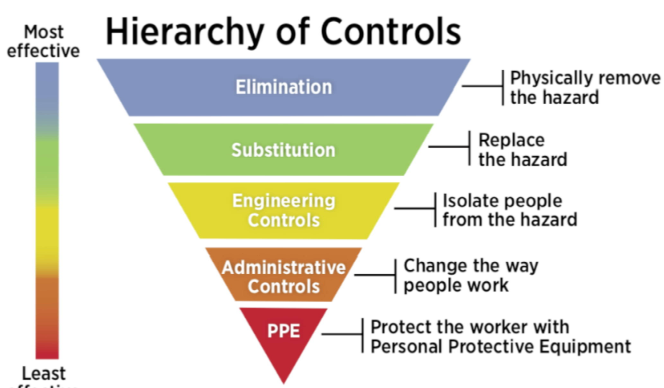
Designing for Safety became known as "Safety by Design" and more recently "Prevention through Design" or PtD. The NFPA NEC Correlating Committee is in the process of establishing a task group to create an informative annex of the National Electrical Code, with the intent to stimulate the application of Prevention through Design (PtD) concepts in electrical designs.

Currently, the NEC provides a rule-based approach to help assure minimum requirements to safeguard people and property from electrical hazards. This new proposed annex is intended to help designers understand how to better reduce remaining risks. NELSON has been asked to be part of this task group due to our unique experience and grasp of PtD principles and it is an honor for NELSON to again be at the forefront of advancing our profession. The proposed annex will be part of the public input process for creating the 2023 edition of the NEC and therefore must be complete by December of this year. This is the first attempt at developing a risk-based approach similar to the EU directive for electrical system designs on a national level. If we do our jobs well, we will hopefully witness a similar reduction in occupational electrocution fatality rates and reduced injuries currently enjoyed by the UK.

A Difference Between US and UK
Credit: 2019 IEEE IAS ESW Tutorial Preservation Through Design; Larry Floyd 2019

But what is Prevention through Design? PtD encompasses all of the efforts to anticipate and design out hazards to workers in facilities, work methods and operations, process equipment, tools, products, new technologies and the organization of work.

The National Institute for Occupational Safety and Health Initiative developed the following Hierarchy of Controls forming the basis of prevention through design. This hierarchy provides a systematic approach to avoiding, eliminating, controlling, and reducing risks considering steps in a ranked and sequential order, beginning with elimination and substitution. Any residual risks that have not been eliminated by design are managed using engineering controls, such as safe work practices, warning systems, administrative controls and personal protective equipment. These lesser effective controls get incorporated during construction, operation, maintenance, and ultimate demolition or disposal. The intent is to move safety from an afterthought during construction, operations, maintenance, and ultimate demolition or disposal to the forethought at the beginning of the design. Under this hierarchy, the most effective control, at the top of the inverted triangle, is hazard elimination progressing to the least effective, Personal Protective Equipment (PPE). This doesn't mean that PPE shouldn't be used, but only that it is the last line of defense in protecting the worker. If we could eliminate the hazard during design, none of the less effective controls would be needed because the hazard wouldn't exist. For example, instead of lighting a swimming pool with electric lights, consider not incorporating under water lighting in the design of the pool to prevent the introduction of electric shock hazards. If the client insists on underwater lighting, the designer may

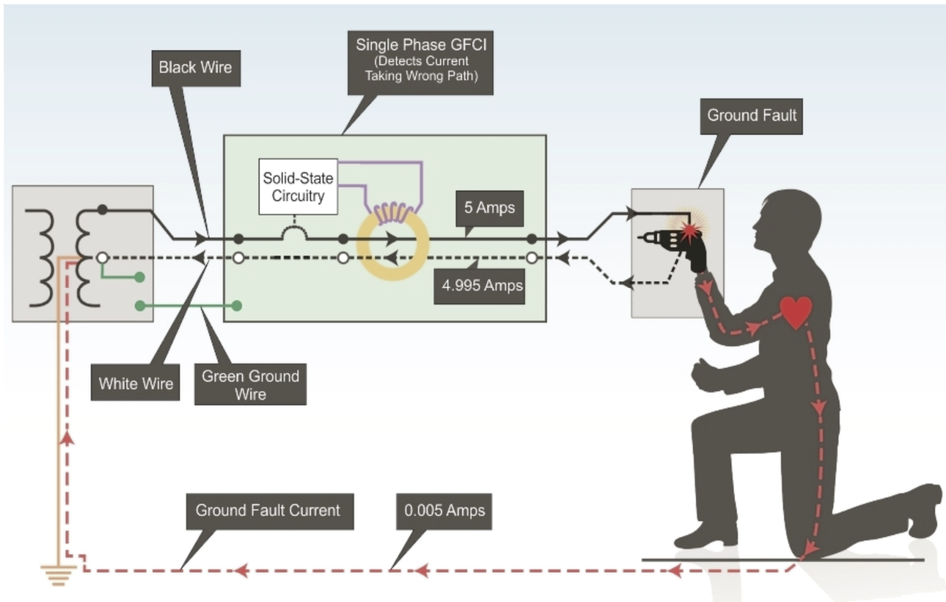


Recommended Practices for Safety and Health Programs
Published October 2016

consider specifying 12-volt underwater pool light fixtures, instead of the typical 120-volt fixtures and just meeting the legal requirements of the NEC. Article 680 of the NEC states that underwater pool lights shall be listed for the intended use and installed in accordance with the requirements of the National Electrical Code. This design consideration of substituting 120 volt fixtures with 12-volt fixtures reduces, but does not eliminate, the hazard.

It has been found that countries placing more emphasis on design controls during initial design see a reduction in serious injuries and fatalities throughout the life cycle of the product, process or facility. The life cycle of a product, process or facility begins during conceptual design and continues through final design, construction (or fabrication), operations and ultimate disposal or removal.

The following Ground Fault Interrupter (GFCI), is a PtD "Engineering Control" example that may be familiar to most.



GFCI Operation

GROUND FAULT CIRCUIT INTERRUPTER (GFCI)

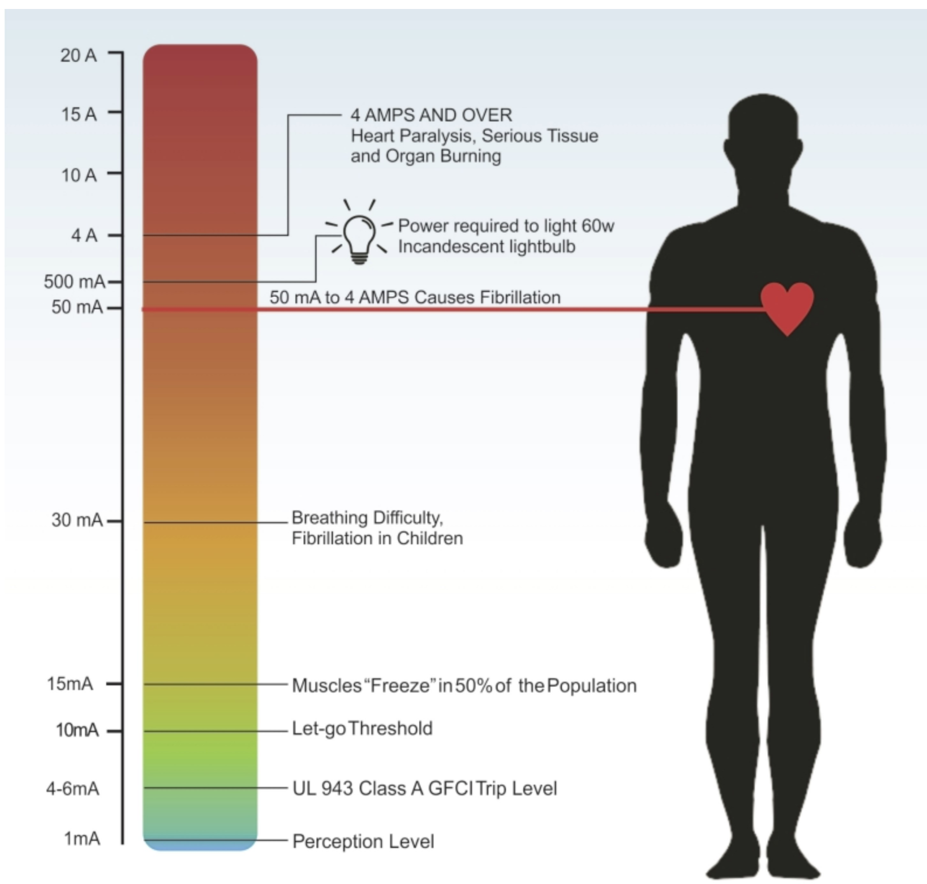
What are GFCI's? These devices are intended to protect personnel against injury, shock and the electrocution hazard associated with using plug and cord attached electrical equipment.

GFCI's ensure all current more that 0.004 to 0.006 amps leaving a receptacle return to the same receptacle or trip within 0.025 seconds, or less, to protect personnel from being electrocuted. To put this current magnitude into perspective, a common 60W light in our homes uses 0.5 amps (500 MA).

If more than 0.004 to 0.006 amps leave the receptacle, but do not return to the same receptacle, there is a possibility that this "leakage" current could be passing through a person as indicated.

A direct correlation between GFCI use and a reduction in electrocutions can be seen on the graph (see page 4).

One word of caution, in 1975 when GFCI use in bathrooms was added to the list of NEC requirements, almost all fixtures in the bathroom were grounded through metal drains and or metal water pipes. This grounding provided a current path for the GFCI to trip, if for example, a hair dryer was dropped in the bathtub or sink. However, with the advancements in modern plumbing using plastic bathtubs, drains, and water supplies, this ground path no longer exits. A hair dryer with a non-immersion rated GFCI would continue energized even if dropped in the water and create a shock or electrocution hazard. It is important when purchasing a hair dryer for use in the bathroom to look for immersion protection to eliminate this hazard.



Physical effects of electric current through body.

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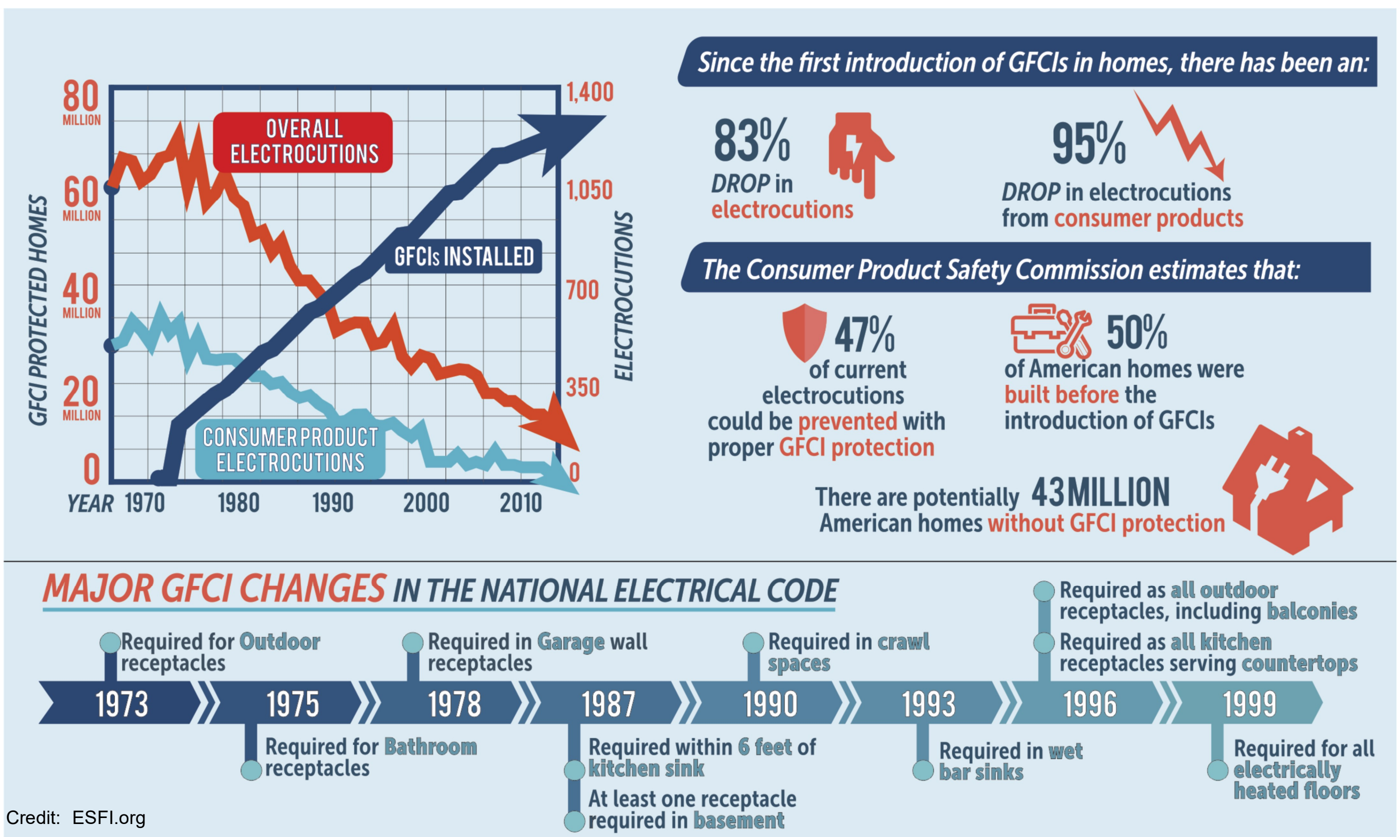

Credit: ESFI.org