An ESFI White Paper

Occupational Electrical Accidents in the U.S., 2003-2009

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INTRODUCTION

The Electrical Safety Foundation International (ESFI) is a non-profit organization dedicated exclusively to promoting electrical safety at home and in the workplace. Founded in 1994 as a cooperative effort by the National Electrical Manufacturers Association (NEMA), Underwriters Laboratories (UL), and the U.S. Consumer Product Safety Commission (CPSC), ESFI is funded by voluntary contributions from electrical manufacturers, distributors, independent testing laboratories, retailers, insurers, utilities, safety organizations, and trade and labor associations.

To better promote electrical safety in the workplace, ESFI seeks to provide objective data on occupational electrical accidents to help decision-makers better allocate safety resources so they may have the maximum impact. This paper builds on earlier work[1] by the National Institute for Occupational Safety and Health (NIOSH) and supplements it with new information on electrical accidents as it becomes available. The data in this report cover U.S. occupational electrical accidents that occurred from 2003 to 2009. These data include the total number of electrical injuries and fatalities, the industries and occupations in which they occurred, and the rates of electrical injury and fatality for selected industries.

BACKGROUND

The information in this white paper has been compiled from data published by the U.S. Bureau of Labor Statistics (BLS) and the U.S. Census Bureau. The BLS categorizes injuries and fatalities using the term "Event" to describe the manner in which the injury or illness was inflicted or produced. The BLS Event categories directly related to electrical injury are:

- 3100 - Contact with electric current, unspecified;
- 3110 - Contact with electric current of machines, tools, appliances, or light fixtures;
- 3120 - Contact with wiring, transformers, or other electrical components;
- 3130 - Contact with overhead power lines;
- 3140 - Contact with underground, buried power lines;
- 3150 - Struck by lightning, and;
- 3190 - Contact with electric current, not elsewhere classified (n.e.c.).

[1] [2008] Trends in Electrical Injury in the U.S., 1992–2002, Cawley, J., G. Homce, *IEEE Transactions On Industry Applications*, Vol. 44, No. 4, July/August, pp. 962-978.

"Nature of Injury" is a BLS category used to describe the principal physical characteristic of the worker's injury or illness. The two BLS Nature of Injury categories used to describe electrical injury are:

- Electric shock, and;
- Electrical burn.

Each year the BLS performs its Census of Fatal Occupational Injuries (CFOI) - an actual count, or census, of fatal injuries. Each case is verified by two or more independent sources of information. Such sources can include death certificates, police reports, news reports, OSHA reports, etc. Similarly, to estimate the number of nonfatal injuries and illnesses, the BLS performs its Survey of Occupational Injuries and Illnesses. Nonfatal injuries, due to their sheer number, are statistically estimated based on a large annual survey of injuries reported by employers.

DISCUSSION

The following discussion describes the information found in tables and charts attached as Appendix A to this document.

Table 1 - Total fatalities from all causes, 2003 – 2009, shows all causes of occupational fatality by Event code. The Events that caused occupational fatality are rank ordered by total number of fatalities. This table includes all fatalities to workers over the age of 16 in Private Industry, military personnel, the self-employed, and government employees.

Electrical fatalities rank seventh, making up about 4% of all occupational fatalities. We will look at electrical fatalities and injuries in more detail in the tables and charts that follow. This general order of Events (Transportation accidents, falls, struck by, etc.) is common to many industries and occupations.

Table 2 - Fatal electrical injuries for all industries, by Event, 1992-2009, includes results from 1992 to 2002 for trending purposes[2], in addition to those for 2003-2009. The totals and percentages reflect the entire period from 1992 to 2009, during which 4,931 electrical fatalities occurred. The largest number of fatalities arises from "Contact with overhead power lines" in every year shown on the table. This Event category includes overhead power line fatalities from direct contact by a worker, contact through hand-carried objects, and contact through machines and vehicles. Overall, the second-largest electrical Event category is "Contact with wiring, transformers, or other electrical components", involving about 27% of electrical fatalities. However, preliminary fatality data for 2009 show that the number of "Contact with wiring, transformers, or other electrical components" and overhead power line contact fatalities were roughly comparable. This occurred because overhead power line contact fatalities declined by 40% while "Contact with wiring, transformers, or other electrical components" fatalities rose by 33%.

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[2] Strictly speaking, the data for 1992-2002 may not be directly comparable to data from 2003 and after. This is due to changes in way BLS categorizes certain industry and occupation data. For a complete explanation of BLS differences see http://www.bls.gov/iif/osh_naics.htm .

Table 3 - Number of electrical fatalities, Private Industry, 2003-2009. Although Table 1 shows 1,573 electrical fatalities, this table shows only 1,479. This is due to two factors. First, Table 3 excludes fatalities to workers under 16 years old, military, and government employees. Second, it is sorted by the Industry in addition to the Event whereas Table 1 was sorted only by Event. Both of these things serve to lower the total number of electrical fatalities reported to 1,479.

Table 3 shows that the construction industry represents 52% of the total electrical fatalities; professional and business services, 13%; trade, transportation and utilities, 11%, and; manufacturing, 9%.

Table 4 - Nonfatal electrical injuries involving days away from work, Private Industry, by Event, 1992-2009. This table includes nonfatal injuries that occurred from 1992 to 2009 for trending purposes. The totals and percentages reflect the period from 1992 to 2009. There were 64,858 electrical injuries estimated for the period. It is instructive to note that while "Contact with overhead power lines" is involved with 43% of fatal electrical accidents, it is involved with only 3% of nonfatal accidents. There were 310 nonfatal and 691 (from Table 2) fatal power line contact incidents reported from 2003 through 2009. *Nearly 70% of 1,001 reported power line contacts resulted in death.* Clearly, when "Contact with overhead power lines" occurs, it is often fatal.

Nonfatal electrical injury most often occurs from "Contact with the electric current of machines, tools, appliances, or light fixtures". This type of injury is one that often results from defective power cords, open grounding circuits, etc. The injured person is often a casual user of an electrical tool, device, or apparatus. Another common nonfatal electrical injury results from "Contact with wiring, transformers, or other electrical components". Such injuries often result from direct contact with components of electrical distribution or utilization circuits and are often sustained by electrical workers. We will examine rates of injury in some of the charts that follow.

Table 5 - Median number of days away from work for nonfatal electrical injuries, by Event, 1992-2009. This table includes results from 1990 to 2009 for trending purposes. The totals and percentages reflect the entire period from 1992 to 2009. The Event "Contact with overhead power lines" routinely has the highest median number of days away per injury, even more (except for 2004, 2007-2009) than for the Event "Struck by lightning". Occasional data points have very high values - the available data do not permit a more in-depth analysis of these points.

Table 6 - Occupational groups with the most fatal electrical injuries, 2003-2009, reflects the Industry structure and the job structure within that Industry. There are 1,260 fatalities by occupation shown on this chart, representing 80% of the total electrical fatalities. The percentages are shown using a denominator of 1,573, the total electrical fatalities from Table 1.

The five occupations shown for construction trades employees represent 32% of the total electrical fatalities reported for the period. Fatalities to electrical power line installers, repairers alone represent nearly 8% of total electrical fatalities.

Table 7 – Fatal electrical injuries by selected worker characteristics, all U.S., all ownerships, 2003-2009. New for 2009, Table 7 depicts the total number of fatal electrical injuries by year versus employment status, gender, age, race, source of injury, nature of injury, part of body, work activity, location, and industry. A detailed examination of Table 7 leads to several interesting observations about electrical victims. In 2009, all of the 168 fatalities were men; the self employed were about 23% of all occupational deaths but only 18% of electrical deaths; 72% were white, 7% were black, 18% were Hispanic; 99% died of electrocution; 70% were constructing, repairing or cleaning something at the time of death; 36% died on industrial premises, 24% at a private residence, and 17% in a public building, and; 96% were employed in private industry.

INJURY RATES

Rates of electrical injury normalize the data for exposure to a hazard, thus better describing the hazard to a particular group. For example, rates allow direct comparison between industries or occupational groups of different size. The rates of electrical injury shown in the figures as follows:

(Incidents / Employment) x Multiplier

where incidents are the total fatal or nonfatal electrical accidents for a given group, employment is the total number of workers who are members of the group, and the multiplier is 100,000 workers for fatal injuries or 10,000 workers for nonfatal injuries. This representation allows us to express a fatality rate as the number of deaths per 100,000 workers or nonfatal injuries per 10,000 workers.

Figure 1 - Fatality rates for all causes vs. electrical causes, 2003-2009 demonstrates that the electrical fatality rate has consistently run at 3-5% of the fatality rate from all causes from 2003 to 2009.

Figure 2 -Electrical fatality rates, by Event, 2003-2009, shows electrical fatality rates per 100,000 workers categorized by Event. Notice that “Contact with overhead power lines” has the highest fatality rate, followed by “Contact with wiring, transformers, or other electrical components” (work that would be normally considered electrical work), and “Contact with electric current of machines, tools, appliances, or light fixtures” (work not normally considered electrical work). The rate for “Contact with overhead power lines” dipped to 0.044 and the rate for “Contact with wiring, transformers, or other electrical components” rose to 0.042, essentially equal. Both figures are subject to revision in the coming year. The rate for “Contact with electric current of machines, tools, appliances, or light fixtures” remained comparable to the 2008 figure. Other fatal electrical injury rates remained below the overall fatality rate for all industry.

Figure 3 - Electrical fatality rates for selected industries, Private Industry, 2003-2009, shows that the utility and mining industries vie for the highest rate of electrical fatality, closely followed by the construction industry, and, less closely by the agricultural industry. The overall electrical fatality rate for Private Industry is shown for reference. These four industries consistently have electrical fatality rates in excess of the Private Industry rate.

Figure 4 - Utility industry, selected electrical fatality rates, by Event, 2003-2009, gives a more detailed look at the 80 electrical fatalities that occurred in the utility industry. Looking at the fatality rates per 100,000 workers allows us to normalize the electrical fatality data in this industry against that of other industries. As might be expected, the highest rate of electrical fatalities occurs from overhead power lines, followed by "Contact with electric current of machines, tools, appliances, or light fixtures". The electrical fatality rate for Private Industry is shown for reference. The utility industry performance improved dramatically in 2009 after being as much as 12 times the electrical fatality rate for Private Industry.

Figure 5 - Mining industry, selected electrical fatality rates, by Event, 2003-2009, presents a breakdown by Event for the 53 electrical fatalities that occurred in the mining industry. The fatality rates are rather high and variable due to the relatively low employment (about 700,000 in 2009) in the mining industry. Data points omitted from the figure reflect data not published by BLS. The two Events with the highest fatality rates are "Contact with overhead power lines" and "Contact with wiring, transformers, or other electrical components". The electrical fatality rate for mining improved dramatically in 2008 from its 2007 performance and declined slightly again in 2009.

Figure 6 - Construction industry, selected electrical fatality rates, by Event, 2003-2009, shows that the Event with the highest fatality rates is "Contact with overhead power lines", which trended generally downward from 2003 to 2009. "Contact with wiring, transformers, or other electrical components" shows no clear improvement increasing slightly in 2009 over the 2008 rate. "Contact with electric current of machines, tools, appliances, or light fixtures" has remained near the fatality rate for Private Industry throughout the period. For 2003-2009, the construction industry had the highest number of electrical fatalities of any industry, with about 52% of all occupational electrical fatalities. The electrical fatality rate for Private Industry is shown for reference. The electrical fatality rate for construction has improved from 1.4 to 0.95 fatalities per 100,000 workers.

Figure 7 - Agriculture, forestry, fishing and hunting industry, selected electrical fatality rates, by Event, 2003-2009, shows that the agriculture industry has a number of electrical fatalities comparable to the utility and mining industries. The leading cause of electrical fatality in agriculture is "Contact with overhead power lines" closely followed by "Contact with electric current of machines, tools, appliances, or light fixtures". The electrical fatality rate in agriculture peaked in 2005 in 2006 at 0.8 fatalities per 100,000 workers, about 4 times the rate for Private Industry. The electrical fatality rate has since improved to near Private Industry levels in 2009.

Figure 8 - Nonfatal electrical injuries, Private Industry, by Nature of Injury, 2003-2009, examines nonfatal electrical shock or electrical burn injuries for selected private industries. The BLS categorizes electrical injury into only two Nature of Injury categories (electric shock and

electrical burns) and does not differentiate between types of electrical burns. For example, one type of electrical burn that is currently under intense scrutiny is the arc flash burn. Another type of electrical burn is the electrical conduction burn in which electrical current passes directly through a body part and damages it by I^2R heating. Unfortunately, the BLS data do not permit isolation of different types of electrical burns.

There were 18,460 electrical shock and electrical burn injuries when categorized by both Nature of Injury and Industry. Figure 8 shows that the greatest number of nonfatal electrical injuries occurs in the construction industry followed by the manufacturing industry. The number of electrical burns exceeds the number of electric shocks in both the construction and utility industries. In all other industries the number of electric shock injuries exceeds that of electrical burns.

Figure 9 - Nonfatal electrical injury rates, by Nature of Injury, Private Industry, 2003-2009, shows that the rate of electric shock injuries held steady at about 0.2, and the rate of electrical burn injuries held steady at 0.1 per 10,000 workers, from 2003 through 2009.

Figure 10 – Nonfatal electrical injury rates, by Event, Private Industry, 2003-2009. Here we see that the injury rates for "Contact with electric current of machines, tools, appliances, or light fixtures" and "Contact with wiring, transformers, or other electrical components" remained comparable from 2008-2008 but that the former experienced a sharp increase in 2009 to nearly double its 2008 rate. Contact with power lines (overhead or buried) is shown not to be a significant source of nonfatal electrical injuries.

Figure 11 – Number of electrical injuries, by Event, Private Industry, 2003-2009. This chart presents the *number* of nonfatal electrical injuries whereas Fig. 10 presents rates of injury. The curves are similar in appearance to those in Fig. 10 and are a graphical representation of Table 4.

Figure 12 - Rates of nonfatal electric burn injury for selected industries, Private Industry, 2003-2009. The utility industry clearly has the highest rate of nonfatal electric burn injury peaking at approximately 2.7 per 10,000 workers in 2006 with a dramatic fall to 0.9 in 2008 and rebounding to 1.1 in 2009. The construction industry electrical burn injury rate remained between 0.5 and 1.0 during the entire period with no clear trend up or down. The mining industry data are relatively sparse, making it difficult to determine any trends.

Figure 13 - Rates of nonfatal electric shock injury for selected industries, Private Industry, 2003-2009. The electric utility industry has the highest rate of electric shock injury. It has increased from 0.3 per 10,000 workers in 2005 to 0.7 in 2009. **T**he construction industry, which had the highest rate of electric shock injury from 2004-2007, improved to 0.4 in 2008 and increased to 0.5 in 2009. The manufacturing industry hovered at 0.3 for 2003-2005 and improved to the Private Industry rate of 0.2 during 2006-2007, then fell to 0.1 in 2009. The Private Industry rate of 0.2 per 10,000 workers is shown for reference.

Figure 14 - Rates of nonfatal electrical injury in the construction industry, by Event, 2003-2009. The leading nonfatal electrical injury Event in the construction industry is "Contact with wiring, transformers, or other electrical components" (the type of injury you would expect to

happen to an electrical worker) followed by "Contact with electric current of machines, tools, appliances, or light fixtures" (the type of injury you would expect to happen more often to those who use electricity in their work). Injuries due to "Contact with wiring, transformers, or other electrical components" appear to be trending slightly upward, even if we ignore the sharp peak that occurred in 2005. Other types of electrical Events occur at or below the overall nonfatal injury rate for Private Industry (shown for reference). The total number of injuries that occurred in the construction industry is also quite high - 5,470.

Figure 15 - Rates of nonfatal electrical injury in the utility industry, by Event, 2003-2009, shows that the total utility nonfatal electrical injury rate peaked at 3.0 per 10,000 workers in 2006 nearly double the peak construction rate of 1.6 per 10,000 workers in 2005. By far, the leading Event category is "Contact with wiring, transformers, or other electrical components" (the type of injury one would expect to happen to an electrical worker), followed by "Contact with electric current, unspecified", and "Contact with electric current of machines, tools, appliances or light fixtures". Note the absence of nonfatal "Contact with overhead power line" injuries. The utility industry sustained 730 electrical injuries, or about 1/7 the number that occurred in the construction industry although it employment is 1/11 that of construction. The rate of Private Industry nonfatal electrical injuries is shown for reference.

SUMMARY

The Electrical Safety Foundation International has compiled the occupational electrical injury experience of the major industries and occupations from data available through the U.S. Bureau of Labor Statistics for the period 2003 through 2009.

A total of 38,124 occupational fatalities occurred from all causes and 1,573 of those were due to contact with electric current. The construction industry had the highest number of electrical fatalities (772), followed by professional and business services (188), trade, transportation, and utilities (164), natural resources and mining (136), and manufacturing (126). Just five occupations in the construction trades - electricians, construction laborers, roofers, painters, and carpenters - experienced nearly 32% of *all* electrical fatalities, electrical power line installers about 8%, and tree trimmers about 5%.

All of the 168 electrical fatalities during 2009 were men; the self employed were about 23% of all occupational deaths but only 18% of electrical deaths; 72% were white, 7% were black, 18% were Hispanic; 99% died of electrocution; 70% were constructing, repairing or cleaning something at the time of death; 36% died on industrial premises, 24% at a private residence, and 17% in a public building, and; 96% were employed in private industry.

In order to fairly compare industries and occupations with different numbers of employees (hence different total exposures to electrical hazards) rates of fatal and nonfatal electrical injury were computed. It was shown that electrical fatalities were approximately 4% of all occupational fatalities each year between 2003 and 2009. "Contact with overhead power lines" was the leading fatal injury Event for the period, but was a minor source of nonfatal electrical injury. "Contact with wiring, transformers, or other electrical components", "Contact with

electric current, unspecified", and "Contact with electric current of machines, tools, appliances or light fixtures", were the next largest fatal Event categories, respectively. Workers in four industries, utilities, mining, construction, and agriculture, forestry, fishing, and hunting experienced electrical fatality rates in excess of the rate Private Industry rate every year between 2003 in 2009. Utility and construction workers also experienced nonfatal electrical injury rates in excess of the Private Industry rate each year between 2003 and 2009.

Appendix A

Tables 1-7 and Figures 1-15