OCCUPATIONS MOST AT-RISK IN FATAL OVERHEAD POWER LINE INCIDENTS: USING OSHA DATA TO GET A BETTER UNDERSTANDING

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Abstract - This paper examines populations injured as a result of contact with overhead power lines. Injured workers are grouped by industry and occupation. Industries with the highest number of fatal overhead power line electrical injuries are, in order, ". . . Power line construction", "Electrical work", "Roofing", "Electric services (utilities)", "Ornamental shrub and tree services", "Asbestos and lead paint removal services", "Painting", and "Concrete work". The occupations with the highest number of fatal overhead power line injuries are, in order, "Electrical power installers and repairers", "Construction laborers", "Supervisors: electricians and power transmission installers", "Laborers, except construction", Construction trades, n.e.c.", "Painters", "Carpenters", "Roofers", "Electricians", and "Truck drivers". Changes in the way Bureau of Labor Statistics data is recorded for electrical injuries have rendered it less useful for hazard analysis and mitigation in the years after 2010. Occupational Safety and Health Administration fatal overhead power line electrical injury data ranges from 22-69% of the number of cases reported by the Bureau of Labor Statistics. The Occupational Safety and Health Administration data also contains narratives that include many incident details such as voltage, equipment involved, and personal protective equipment use and often allows a judgment whether safe work practices were used.

Index Terms — Electrocution, electric shock, overhead power line, electrical safety, occupation, industry.

I. INTRODUCTION

Each year since 1992, when the Bureau of Labor Statistics (BLS) began its Census of Fatal Occupational Injury (CFOI) database, overhead power line (OHPL) injury events have outnumbered all other types of electrical injury. Contact with OHPL injuries comprised 44% of all electrical fatalities from 1992-2010, followed by contact with wiring, transformers, or other electrical components (27%) and contact with electric current of machines, tools, appliances, or light fixtures (17%). Many assume that OHPL injuries occur only to those in occupations whose work involves OHPLs. An examination of the data shows that many other occupations experience a significant number of OHPL fatalities. While occupations like "Electrical power line installers and repairers" and "electricians" account for a significant number of OHPL injuries so do "construction laborers", "painters", "roofers", and truck drivers".

Recent changes to BLS recordkeeping limit its usefulness when examining electrical injuries. Publicly available BLS data do not provide incident narrative information. The Occupational Safety and Health Administration (OSHA) data contain narratives that often include incident details such as voltage, equipment involved, and personal protective equipment use and often allow a judgment whether safe work practices were used. Fatal and nonfatal electrical injury data from the Occupational Safety and Health Administration (OSHA) is compared to BLS data to determine whether OSHA data can be used to study OHPL as a substitute for BLS data.

II. THE DATA

A. The Data

The BLS tabulates its data by "Event", a category which describes the manner in which the injury is inflicted. Until 2010 the Event structure used to describe electrical injury was:

3100 - Contact with electric current, unspecified
3110- Contact with electric current of machine, tool, appliance, or light fixture
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
3190 - Contact with electric current, n.e.c.

This Event structure allows for an efficient identification of major categories of electrical injuries useful to engineers interested in developing hazard training and mitigation strategies. Beginning with the 2011 injury data, BLS changed its Event structure, eliminating the above Event categories and substituting a voltage-based Event structure as shown below:

510 Exposure to electricity, unspecified
511 * Direct exposure to electricity
Includes: arc flashes, direct contact with power lines, electric fences
5110 Direct exposure to electricity, unspecified
5111 Direct exposure to electricity, 220 volts or less
5112 Direct exposure to electricity, greater than 220 volts

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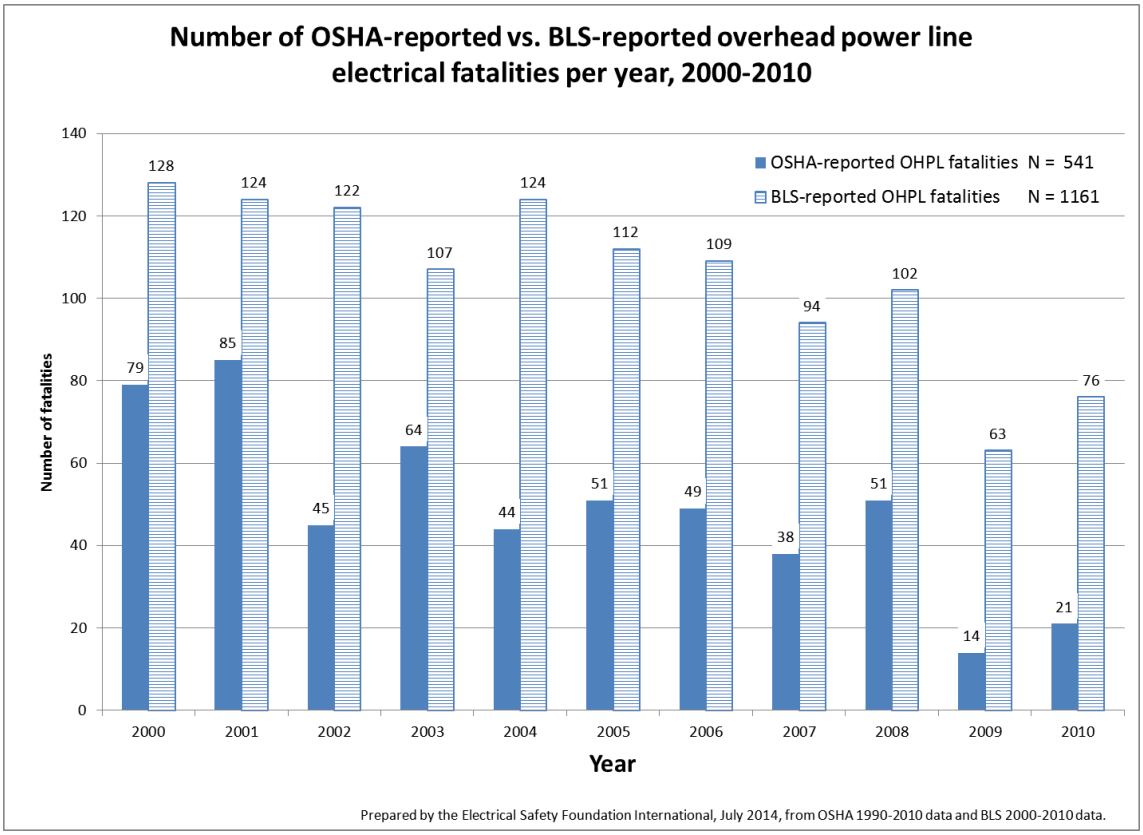

Figure 1. Number of OSHA-reported v. BLS-reported OHPL electrical fatalities per year, 2000-2010

512* Indirect exposure to electricity
5120 Indirect exposure to electricity, unspecified
Includes: contact with electrified piping or with machinery or equipment that touches live Power lines: electric shock from standing in water.
5121 Indirect exposure to electricity, 220 volts or less
5122 Indirect exposure to electricity, greater than 220 volts

OHPL injuries are now comingled with other injuries in the "511*" Event category and do not readily lend themselves to analysis. This change, coupled with the public unavailability of accident narratives, has reduced the value of CFOI as a resource for mitigating electrical accidents.

B. OSHA Electrical Injury Data Vs. BLS Data

Another widely available source of reliable electrical injury data comes from OSHA. However, unlike BLS data, the OSHA data represent only a sample of electrical injuries; it is not a census. BLS data are accepted by the National Safety Council as the definitive count of occupational injury from all sources in the U.S. Just how well does the OSHA data represent its BLS counterpart? Figure 1 compares the number of OSHA-reported and BLS-reported OHPL fatalities in the U.S. from 2000-2010. Figure 2 shows the percentage of OSHA-reported OHPL fatalities vs. BLS-reported OHPL fatalities. OSHA-reported fatal cases range from 22-69% of the number reported by BLS.[1]

While not ideal, this level of consistency between the databases should allow for examination of electrical injury cases using the OSHA-provided narrative account that accompanies each case. Such narrative information is not publically available from BLS. The percentage of OSHA-reported cases has declined to 22 and 28% for 2009 and 2010, respectively, calling the continued reliance upon OSHA-reported electrical fatality data as a proxy for BLS data into question. For the period from 2000-2011, however, this paper will use OSHA-reported electrical fatality data to draw inferences about the sample population of electrical injuries among industries and occupations.

III. AT-RISK POPULATIONS

A. OHPL Fatalities by Industry

OSHA reported 552 worker deaths attributed to electrical injuries sustained while working in proximity to OHPLs from 2000-2011. OHPL fatalities in selected industries, as reported by OSHA, are enumerated in Table 1.

[1] Such is not the case for non-fatal injury data. OSHA-reported only 3.8-6.2% of the number of non-fatal electrical injury cases reported by BLS from 2000-2011. This level of reporting renders OSHA electrical injury data a doubtful proxy for BLS data. OSHA is not charged with investigating all reports of nonfatal injury.

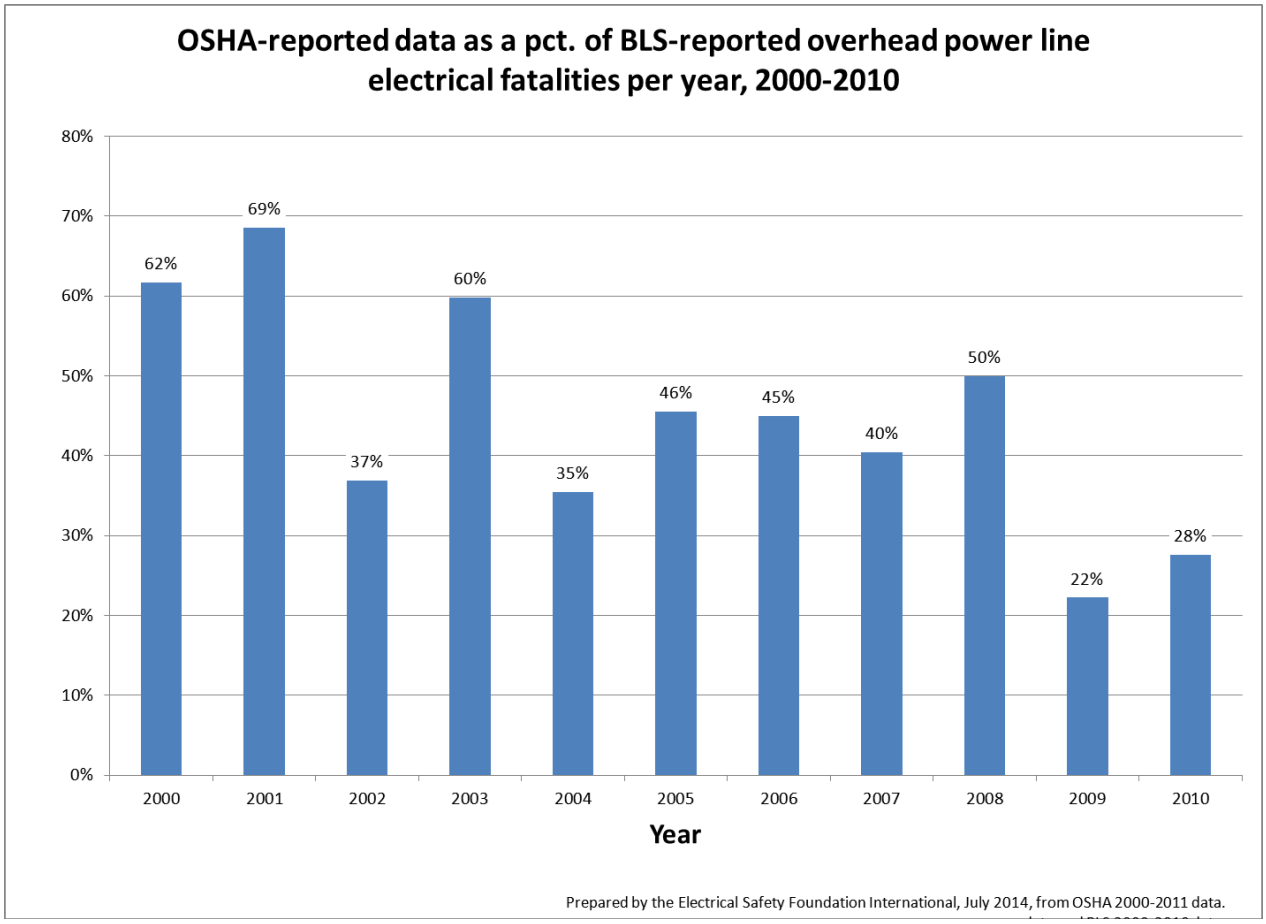

Figure 2. OSHA-reported OHPL fatality data as a percent of BLS-reported electrical fatalities each year, 2000-2010.

Table 1. OSHA-recorded overhead power line fatalities by industry, 2000-2011

Industry	No. of Cases
Water, Sewer, Pipeline, and Communications and Power Line Construction (power and communications transmission lines)	80
Electrical Work (electrical work except burglar and fire alarm installation)	51
Roofing, Siding, and Sheet Metal Work (except roofing and siding work)	51
Electric Services (electric power distribution)	47
Ornamental Shrub and Tree Services	32
Special Trade Contractors, NEC (asbestos abatement and lead paint removal contractors)	23
Painting and Paper Hanging	21
Concrete Work (asphalt, brick, and concrete paving)	18
Highway and Street Construction, Except Elevated Highways	13
General Contractors - Nonresidential Buildings, Other than Industrial Buildings and Warehouses	11
General Contractors - Single-Family Houses (remodeling contractors)	11
Oil and Gas Field Services, NEC (site preparation and related construction activities on a contract basis)	11
Masonry, Stone Setting, and Other Stone Work	10
Water Well Drilling	10

Note: 164 OHPL fatalities in 81 other industries – each with 7 or fewer fatal OHPL injuries - not shown for brevity.

Table 2. Voltage of OSHA-reported OHPL fatalities, 2000-2011.

Voltage	No. of cases	Pct.
<1000V	13	2%
1-5.99kV	23	4%
6-9.99kV	198	36%
10-23kV	106	19%
24-100kV	21	4%
100+ kV	17	3%
Unknown	174	32%

The "Water, Sewer, Pipeline, and Communications and Power Line Construction (power and communications transmission lines)" industry recorded 80 OHPL electrical fatalities from 2000-2011 with 52% of them to linemen and their supervisors. The "Electrical work (electrical work except burglar and fire alarm installation)" industry followed with 51 OHPL fatalities – 41% of them to linemen and their supervisors. The "Roofing, Siding, and Sheet Metal Work (except roofing and siding work)" industry recorded 51 OHPL fatalities. These often occurred when using ladders or scaffolds during the installation of metal gutters, downspouts and flashing on commercial and residential buildings. Surprisingly, the "Electric services (electric power distribution)" industry ranked fourth with 47%. This lower number of OHPL fatalities in the face of very high hazard exposure can be attributed, in part, to the high level of safety training, hazard awareness, and work planning of those employees who work in proximity to OHPLs. Other industries, not among those that would normally come to mind when thinking about OHPL fatalities, are Ornamental Shrub and Tree Services (32 OHPL fatalities), Asbestos abatement and lead paint removal contractors (23), Painting and Paper Hanging (21), Concrete Work (18), Masonry, Stone Setting, and Other Stone Work (10), and Water Well Drilling (10). Each has 10 or more OHPL fatalities during the study period.

Table 2 shows the voltages associated with OHPL fatalities were reported in 378 (68%) of the 552 case narratives. The most common voltage was the 6-9.99kV class (36% of reported cases), followed by the 10-24kV class (19%) and 32% of cases did not report the incident voltage.

As shown in Table 3, contact with OHPLs through incidental contact (OHPL contact while performing a work activity not commonly associated with OHPL hazards) was involved in 68% of the cases studied. Such activities are often performed by construction laborers carrying handheld metallic objects, siding and sheet metal mechanics maneuvering metallic siding or sheet metal flashing into place, and tree trimmers who may not see OHPLs in the trees and shrubs they are pruning. OHPL maintenance activities were involved in 26% of cases, OHPL construction in 5%, and only 1% of case narratives precluded a determination of the fatal work activity.

Table 4 shows the energized object contacted that was most directly the source of electrocution. The most common source of electrocution was contact through an energized tool or object (34%) (hand tools, metal ladders, scaffolds, aluminum siding, etc.), followed by contact with energized conductors (28%), energized vehicles (16%), energized booms, hoist ropes, or loads (11%), or personnel lifts (8%). In 2% of cases a source of electrocution could not be identified. Incidental contact with an OHPL through an energized tool or object is very common.

Table 3. Primary work activity for fatal OHPL incident, 2000-2011.

Work activity	No. of Cases	Pct.
OHPL construction	25	5%
OHPL maintenance	145	26%
Incidental contact	378	68%
Unknown	4	1%

Table 4. OSHA-reported energized equipment or device contacted during OHPL fatality, 2000-2011.

Energized object contacted	No. of Cases	Pct.
Boom/hoist rope/ load	63	11%
Personnel lift	46	8%
Energized conductor	156	28%
Energized tool / object	186	34%
Energized vehicle	88	16%
Unknown	13	2%

B. OHPL Fatalities by Occupation

Table 5 shows that "Electrical power line installers and repairers" and "Supervisors: electricians and power transmission installers" were involved in 91 (16%) of the 552 OHPL electrocutions. These occupations have a high level of hazard exposure, often under adverse conditions, such as repairing storm-damaged OHPLs. They receive comprehensive hazard recognition and mitigation training, but may be tempted to circumvent that training in the field, as documented in the OSHA fatality narrative reports. Such actions can and do sometimes have tragic consequences.

Other occupations listed, such as construction laborers, painters, carpenters, roofers, and truck drivers are not usually thought of as having a significant exposure to OHPL hazards. Yet, each of these occupations has routine exposure to OHPL hazards in the course of its normal work. The category "Other occupations" consists of 95 valid cases in 50 remaining occupations not shown for brevity. "Occupation not reported" includes 247 cases (45% of all reported cases) for which an occupation was not included in the case report.

Separating OHPL fatalities into occupational groups with electrical responsibilities and those without electrical responsibilities leads to three distinct groupings. The largest group, "Occupation not reported", consists of 247 fatalities whose data record did not specify an occupation – the narrative interpretation is the only window into the fatal circumstances. The second group consists of "Electrical power installers and repairers" and "Supervisors; electricians & power transmission installers" with 91 fatalities. The third group consists of the 214 fatalities in the remaining non-electrical occupational groups.

Table 6 shows that OHPL fatal injuries to "Electrical power installers and repairers" and "Supervisors; electricians & power transmission installers" combined are largely concentrated within voltages from 6 to 23kV, the most common ranges for distribution voltages. This occupational group also receives 12% of its OHPL fatalities from voltages over 100kV. The occupational groups "Other reported occupations" and "Occupation not reported" also receive most of their fatal OHPL injuries from voltages of 6-23K.

Table 5. OSHA-reported OHPL fatalities by “Occupation”, 2000-2011.

Occupation	No. of Cases
Electrical power installers and repairers	71
Construction laborers	33
Supervisors; electricians & power transmission installers	20
Laborers, except construction	18
Construction trades, n.e.c.	14
Painters, construction and maintenance	12
Carpenters	11
Roofers	11
Electricians	10
Truck drivers, heavy	10
Other occupations	95
Occupation not reported	247
Total	**552**

Table 7 shows that "Electrical power installers and repairers" and "Supervisors; electricians & power transmission installers" combined are injured by contact with an energized conductor in 77% of the fatal OHPL cases compared to “Other reported occupations” and "Occupation not reported" with 16% and 21%, respectively. However, the latter two groups are injured in 42% and 36% of cases, respectively, by tools or objects (like metal pipes, poles, aluminum siding, metal flashing, etc.) coming into contact with an OHPL. For these two groups, 19% of fatalities occurred when a worker entered/exited a vehicle with an energized frame or when a worker unaware of the hazard touched the vehicle. In “Other reported occupations” and "Occupation not reported", 12% and 14%, respectively, of OHPL fatalities occurred when a worker touched an energized boom, hoist rope, or load of a crane or boom truck.

More detailed information on fatal OHPL injuries in various industries and occupational groups including charts, tables, and narratives of the 552 fatalities used in this study, can be found on the ESFI website at: http://www.esfi.org/index.cfm/event/workplacesafety/pid/10224

IV. ESFI OHPL SAFETY PROGRAM

In 2014, the Electrical Safety Foundation International partnered with AgSafe, a non-profit dedicated to providing the agricultural industry with the education and resources needed to prevent injuries, illnesses, and fatalities. Materials were cooperatively developed to increase awareness of the hazards associated with OHPLs in the agricultural workplace. ESFI created a “train-the-trainer” program that AgSafe will deploy throughout its networks. This will be used to train onsite managers on how to educate their employees to avoid injuries and deaths caused by OHPLs.

ESFI also created a large poster that will facilitate training through the use of text-limited, illustrated tips on how to remain safe while working near OHPLs at agricultural worksites. Both the training program and the poster were reviewed by AgSafe content specialists to ensure that they appropriately deliver the information to the targeted population. 5,000 color posters have been printed and will be distributed at AgSafe’s two upcoming events in early 2015. Posters will also sent directly to AgSafe’s partner organizations. Both ESFI and AgSafe will make the program components available for download on their respective websites.

Table 6. Voltage of OSHA-reported OHPL fatalities (in percent of cases) for selected occupational groupings, 2000-2011.

Occupational grouping	Voltage Range (kV)						
	<1	1 - 5.99	6 - 9.9	10 - 23	24 -100	100+	U *
All cases (N = 552)	2%	4%	36%	19%	4%	3%	32%
"Electrical power installers and repairers" and "Supervisors; electricians & power transmission installers" (N = 91)	3%	4%	44%	19%	0%	12%	18%
Other reported occupations (N = 214)	1%	5%	31%	24%	4%	2%	33%
"Occupation not reported" (N = 247)	3%	3%	37%	15%	5%	1%	35%

Note: * U = unknown voltage.

Table 7. OSHA-reported energized equipment or device contacted by selected occupational groupings during OHPL fatality, 2000-2011.

Occupational grouping	Energized equipment or device, Pct.					
	Boom/hoist rope/ load	Personnel lift	Conductor	Tool / object	Vehicle	U
All cases (N = 552)	11%	8%	28%	34%	16%	2%
"Electrical power installers and repairers" and "Supervisors; electricians & power transmission installers" (N = 91)	4%	9%	77%	8%	1%	1%
Other reported occupations (N = 214)	12%	9%	16%	42%	19%	3%
"Occupation not reported" (N = 247)	14%	7%	21%	36%	19%	2%

Note: * U = unknown voltage.

The agricultural program's future direction will be dictated by feedback received from surveys issued by AgSafe to evaluate the effectiveness of the poster and training program as reported by program participants. ESFI is exploring other industries with which to partner to address the hazards posed by overhead power lines, including but not limited to: utilities, transportation and construction.

V. SUMMARY

The OSHA data was shown to be a reasonable sample of the BLS data for fatal OHPL injuries but such could not be said of nonfatal OHPL injuries. The "Water, Sewer, Pipeline, and Communications and Power Line Construction (power and communications transmission lines)" industry recorded the highest number of OHPL fatalities (80) and the Water, Sewer, Pipeline, and Communications and Power Line Construction (power and communications transmission lines) with the "Electric Services (electric power distribution)" fourth (47 fatalities).

The most often injured occupation was "Electrical power installers and repairers" combined with "Supervisors; electricians & power transmission installers" with 91 OHPL fatalities (16% of fatalities). "Construction laborers" were second with 33 OHPL fatalities (6%).

Many occupations that are not usually associated with OHPL job responsibilities are fatally injured in the course of work performed in the vicinity of OHPLs. Conductive ladders, aluminum siding, sheet metal, metallic poles, and handheld objects are frequent elements in OHPL electrocutions for painters, siding mechanics, and tree trimmers. Too often a desire for work expediency and a failure to recognize the imminent OHPL hazard combine to produce tragic results.

The ESFI has worked with AgSafe to develop training to raise OHPL hazard awareness in the agricultural industry. Such partnerships in the utility, transportation and construction industries can have a substantial impact on reducing the number of OHPL fatalities.

VI. REFERENCES

[1] U.S. Occupational Safety and Health Administration, Integrated Management Information System (IMIS) database, data for years 2000-2011 excerpted from the 1990-2012 data, available online at www.osha.gov/pls/imis/accidentsearch.html

[2] U.S. Bureau of Labor Statistics web page "Injuries, Illnesses, and Fatalities", http://www.bls.gov/iif/#Data, July 2014.

[3] Workplace Electrical Injury and Fatality Statistics - Additional Charts, 2003-2010, available from the ESFI webpage: http://www.esfi.org/index.cfm/page/Workplace-Electrical-Injury-and-Fatality-Statistics-Additional-Charts,-2003-2010/cdid/12398/pid/3003

VII. VITAE

Brett Brenner became President of the Electrical Safety Foundation International (ESFI) in 2005 and has since developed aggressive marketing and awareness campaigns to advance electrical safety. Such successes have established ESFI as the primary source for unbiased electrical safety information to reduce the incidences of fires, injuries and deaths.

Founded in 1994, the Electrical Safety Foundation International (ESFI) is a non-profit organization dedicated exclusively to providing unbiased information regarding electrical safety. ESFI proudly executes a variety of awareness campaigns to address emerging and seasonal electrical safety issues, including National Electrical Safety Month each May. These efforts aim to educate the public and help prevent fatalities, injuries, and property damage resulting from electrical fires in the home, school, and workplace.

James C. Cawley, P.E., is currently a consultant to ESFI specializing in electrical safety statistics. Jim spent thirty years in electrical safety research with the U.S. Government at the Bureau of Mines, the Department of Energy, and the National Institute for Occupational Safety and Health. Among other research interests, his work with NIOSH included research into overhead power line contact by cranes and trucks and electrical accident surveillance in the mining and construction industries.

Jim earned the B.S.E.E. degree from The Pennsylvania State University and the MBA degree from the University of Pittsburgh. He is a Senior Member of the Institute of Electrical and Electronics Engineers and a Registered Professional Engineer in the Commonwealth of Pennsylvania.