Advancements in the Practice of Electrical Safety

IEEE Southern Alberta Section IAS-PES Chapter

May 13-14, 2013

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IEEE Advancing Technology for Humanity

IAS IEEE Industry Applications Society

IEEE PES Power & Energy Society

DuPont The miracles of science

Advancements in the Practice of Electrical Safety

This session will highlight recent developments impacting further improvement in preventing occupational electrical injuries and fatalities. Topics include injury trends, electric shock, arc flash, potential changes to CSA Z462 and NFPA 70E, auditing tools and advanced safety management focused on prevention of fatality and life changing injuries.

Advancements in the Practice of Electrical Safety

I. Statistics and Trends

A. Injuries & Fatalities

B. Who is at risk

II. Standards

A. Role, Limitations and upcoming changes

B. Prevention through Design

C. Maintenance & Reliability

D. Safety Management Systems

III. A 20 Year Case History

A. Significant Improvement is Possible

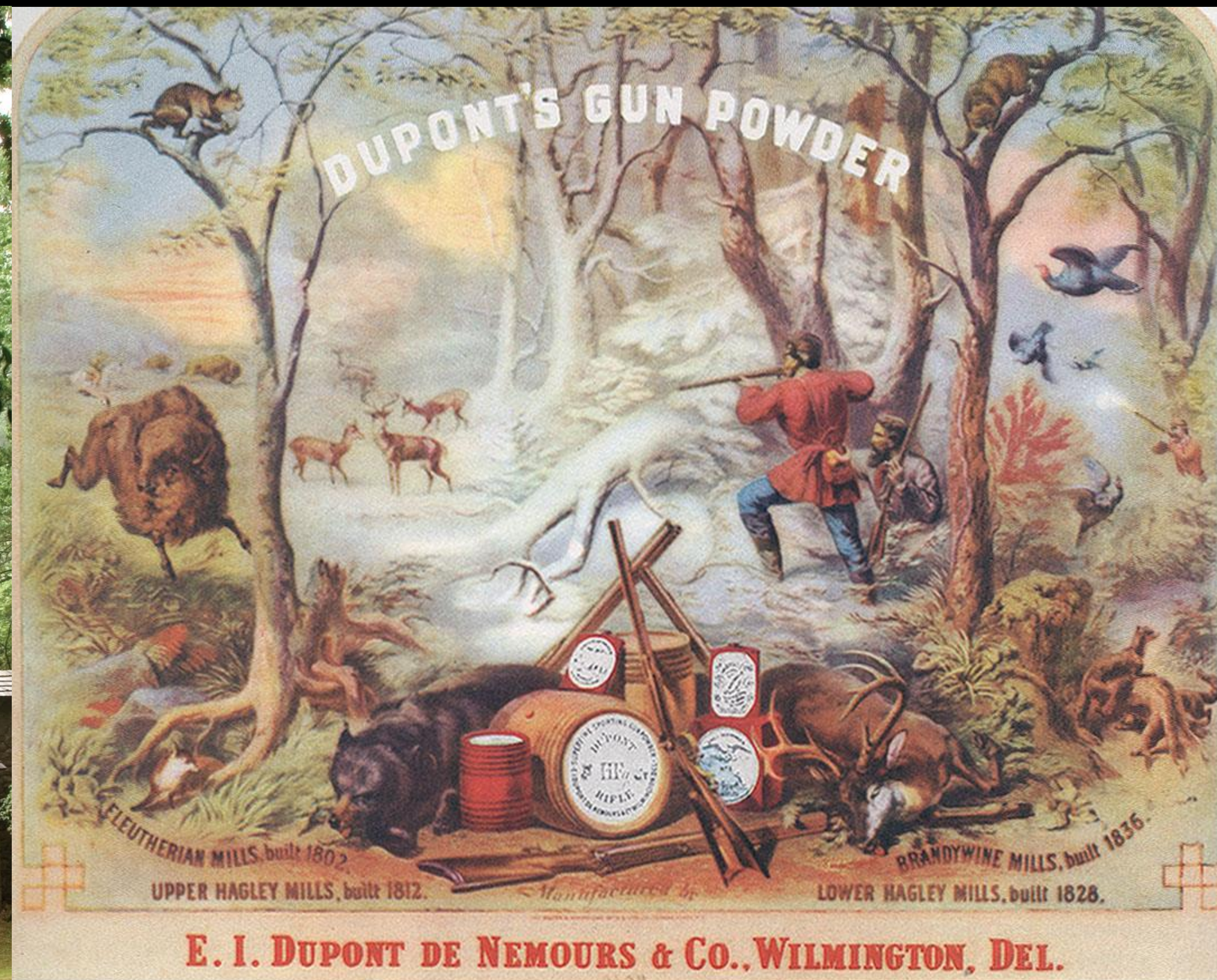
B. Open Discussion

Advancements in the Practice of Electrical Safety

Objectives:

1. **You will gain knowledge that will help enhance support for your electrical safety efforts**
2. **You will gain knowledge on who is most at risk for electrical injury**
3. **You will gain knowledge on how to focus maintenance to help assure reliability of equipment critical to electrical safety**
4. **You will see that significant improvement in electrical safety performance is achievable**

DuPont

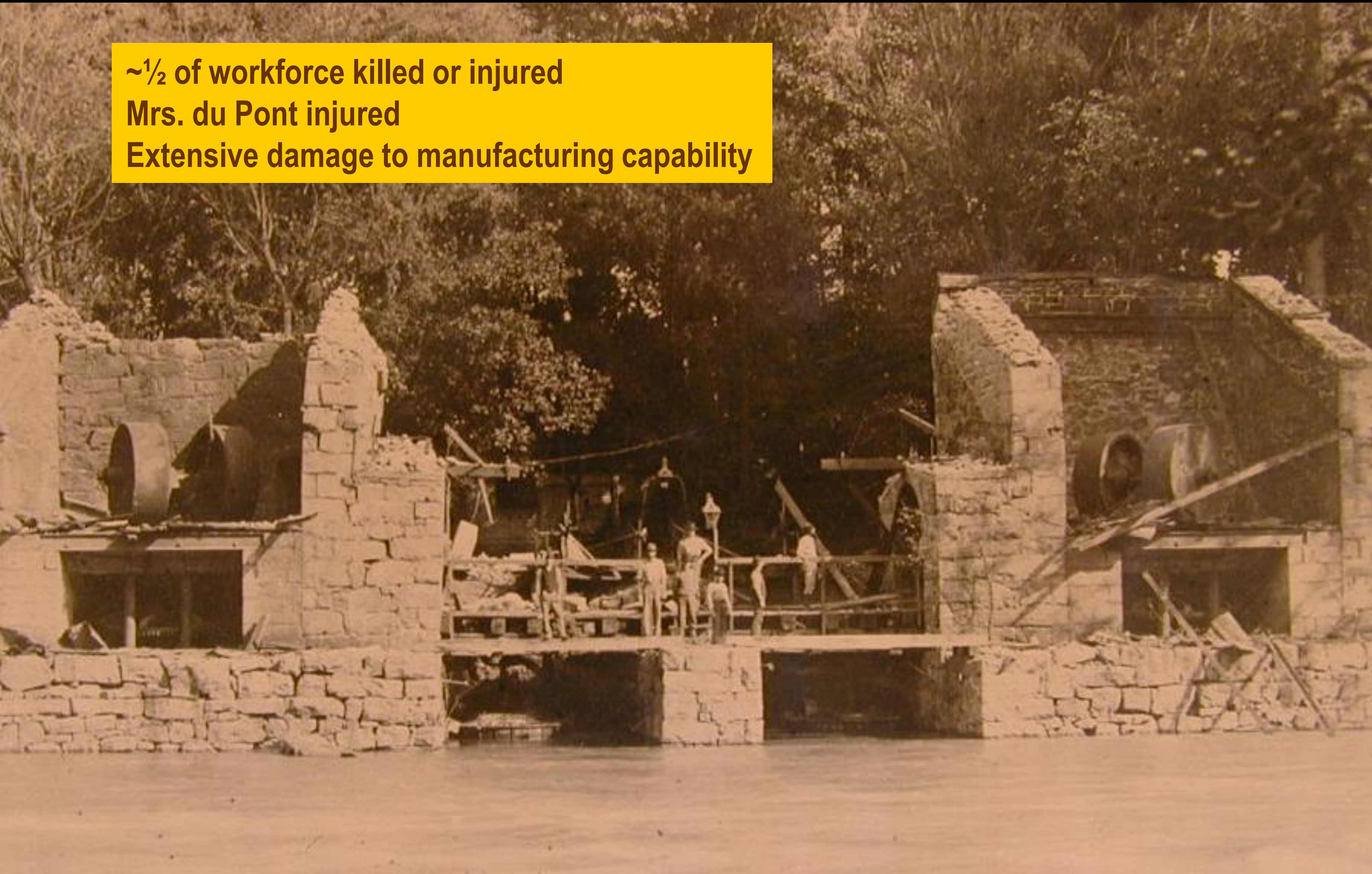


The oldest Fortune 500 company
Established 1802

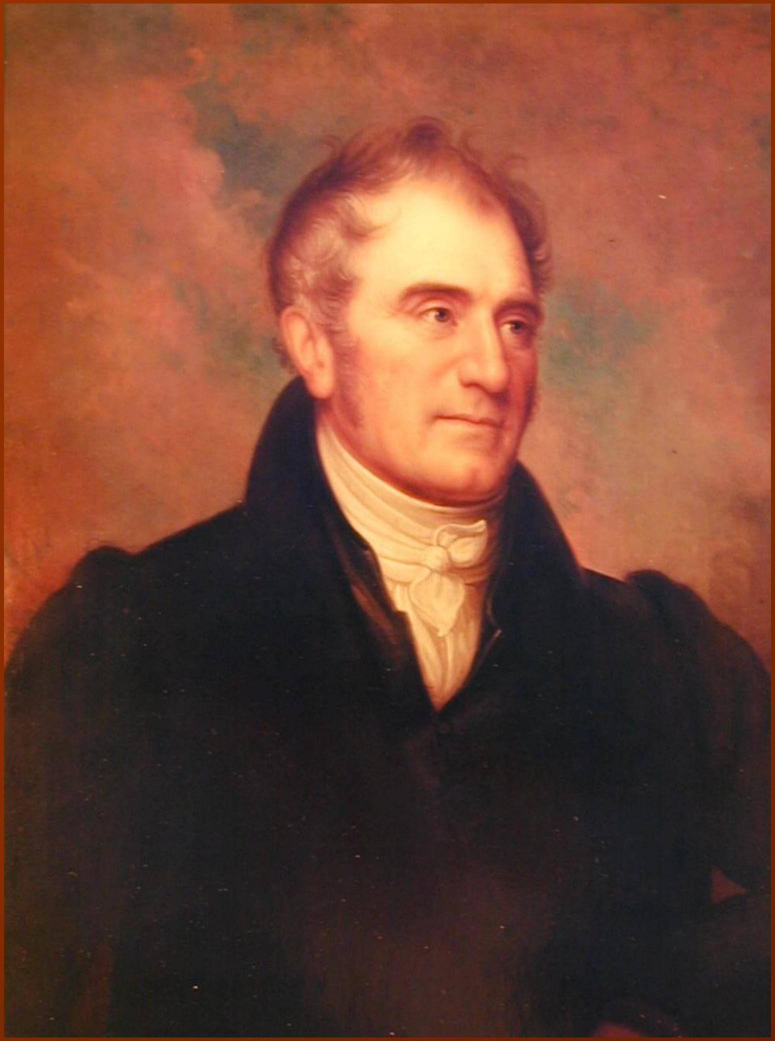
About DuPont

DuPont Explosion 1818

~½ of workforce killed or injured
Mrs. du Pont injured
Extensive damage to manufacturing capability



Safety Established as a Core Value

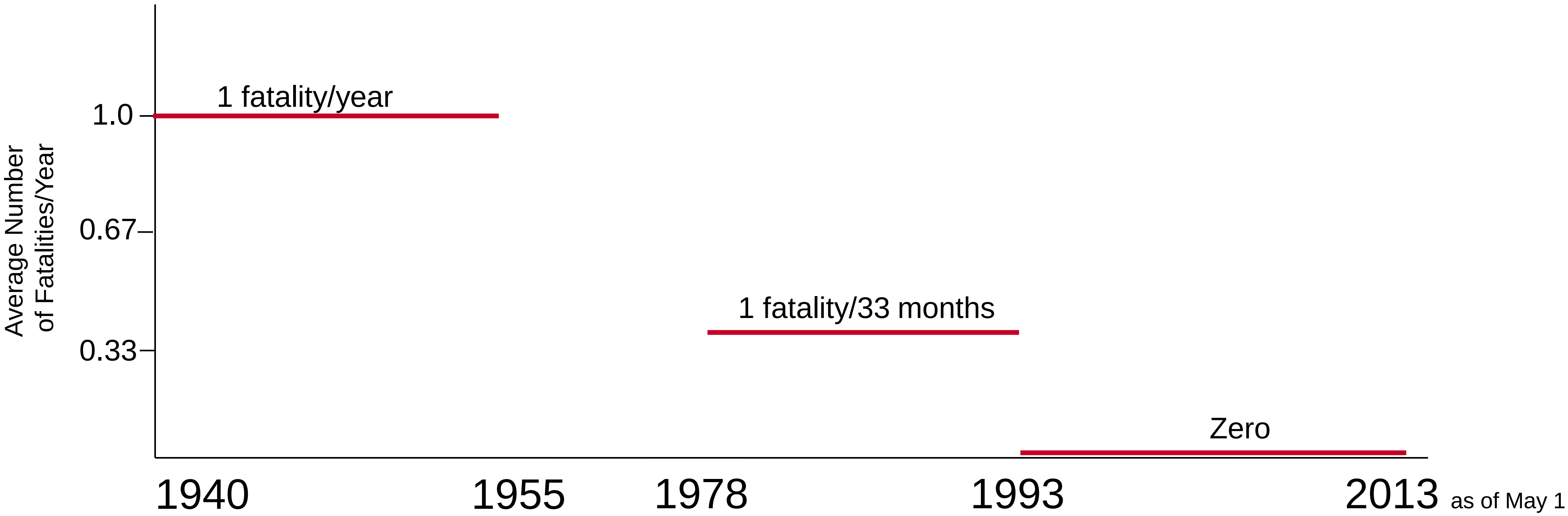


"we must seek to understand the hazards with which we live"

Éleuthère Irénée du Pont

Trends in Electrocution Fatalities in DuPont Operations

Employees and Contractors



Notes

1. No data available for 1955-78
2. 1953 marked beginning of a culture shift to eliminate accepted practice of working on energized circuits
3. Corporate Electrical Safety Team established in 1989 to further shift electrical safety culture in DuPont
   - Focus on near miss incident learnings, line management engagement, improved auditing processes, fundamentals i.e. “Test Before Touch”; Engineering Std E1Z established as default electrical safety performance standard and evolved to SHE Standard S31G in 2003
4. Electrocution in 2001 occurred in Pioneer; within 24 months of acquisition, non-operations, customer service support in customer facility
5. Electrocution remains 5th leading cause of occupational fatality in the US

Statistics and Trends

- **Injuries & Fatalities**
- **Who is at risk**

Injury Facts

search "NIOSH, Cawley, Electrical Injury"

Trends in Electrical Injury in the U.S., 1992–2002

James C. Cawley, *Senior Member, IEEE*, and Gerald T. Homce

***Abstract*—This paper updates an earlier report by the authors that studied electrical injuries from 1992 to 1998. The previous information is expanded and supplemented with fatal and nonfatal injury rates and trends through 2002. Injury numbers and rates were used to compare and trend electrical injury experience for various groups and categories. This information allowed identification of at-risk groups that could most benefit from effective electrical safety interventions. The data presented in this paper are derived from the U.S. Labor Department's Bureau of Labor Statistics' Census of Fatal Occupational Injuries, Survey of Occupational Illnesses and Injuries, and Current Population Survey. Between 1992 and 2002, 3378 workers died from on-the-job electrical injuries. Electricity remained the sixth leading cause of injury-related occupational death. From 1999 to 2002, 4.7% of all occupational deaths were caused by electricity, down from 5.2% in the 1992–1998 time period. The cause of death was listed as electrocution in 99.1% of fatal cases. Contact with overhead power lines was involved in 42% of all on-the-job electrical deaths. The construction industry accounted for 47% of all electrical deaths between 1992 and 2002 but showed overall improvement from 1995 to 2002 by reducing its electrical fatality rate from 2.2 to 1.5 per 100 000 workers. In addition, 46 598 workers were nonfatally injured by electricity. Contact with electric current of machine, tool, appliance, or light fixture and contact with wiring, transformers, or other electrical components accounted for 36% and 34% of nonfatal electrical injuries, respectively. Contact with underground buried power lines was involved with 1% of fatal injuries and 2% of nonfatal injuries. The research of the National Institute for Occupational Safety and Health aimed at evaluating commercially available overhead power line proximity warning alarms is described. This paper is expected to be the initial step for eventual development of a performance standard for such systems.**

***Index Terms*—Electrical burn, electrical injury, electrical safety, electrical shock, electrocution, fatality rate, injury rate.**

groups that could most benefit from effective electrical safety interventions.

A. *Data Sources*

The fatality data presented in this paper are derived from the U.S. Labor Department's Bureau of Labor Statistics' (BLS) Census of Fatal Occupational Injuries (CFOI).[1] For the years between 1992 and 2002, CFOI reports 67 373 occupational fatalities. The database includes incident narratives, the source of injury, the victim's occupation, location of the incident, work activity at the time of the incident, and other details. Each case is verified through at least two documents such as a death certificate, news account, or police report. CFOI fatality numbers include fatal injuries to all workers but exclude deaths from the September 11, 2001 terrorist attacks. Employment data used in this paper to compute fatal injury rates are taken from the BLS Current Population Survey (CPS).[2] CPS data represent civilian workers who are 16 years old or older.

Nonfatal electrical injury data in this paper are derived from the BLS Survey of Occupational Illnesses and Injuries (SOII). SOII provides an estimate of the nonfatal occupational injuries and illnesses that cause days away from work in the U.S. each year. SOII is a cooperative program in which employer survey reports are collected and processed by state agencies cooperating with the BLS. In 2002, for example, 182 000 business establishments were surveyed, representing nearly the entire U.S. private economy. SOII is a statistical estimate based on a stratified sample of industry respondents. It contains no narrative or work activity information.[3] SOII nonfatal injury

Injury Facts

search “EPRI, Yager, Electrical Injury”

Thermal burn and electrical injuries among electric utility workers, 1995–2004

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[b] Exponent Inc., Washington, DC, United States
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A R T I C L E   I N F O

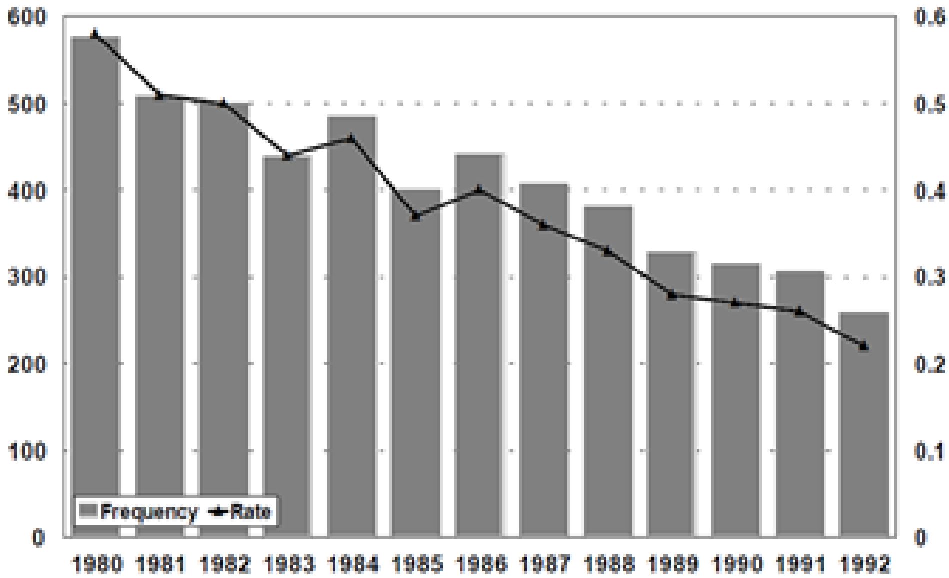
Article history:
Accepted 25 June 2006

Keywords:
Occupational health
Occupational injury
Burn
Thermal burn
Electric shock
Electric utility workers
Burn injuries

A B S T R A C T

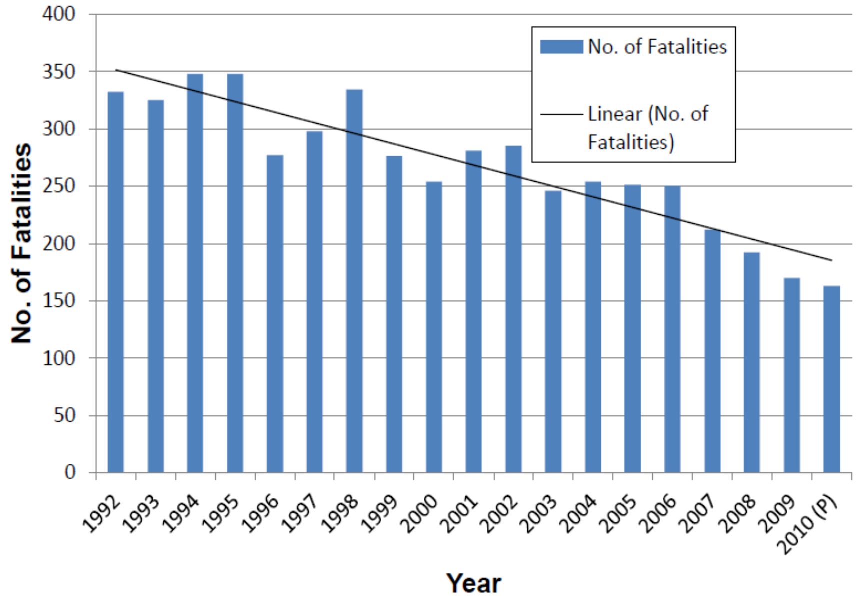
This study describes the occurrence of work-related injuries from thermal-, electrical- and chemical-burns among electric utility workers. We describe injury trends by occupation, body part injured, age, sex, and circumstances surrounding the injury. This analysis includes all thermal, electric, and chemical injuries included in the Electric Power Research Institute (EPRI) Occupational Health and Safety Database (OHSD). There were a total of 872 thermal burn and electric shock injuries representing 3.7% of all injuries, but accounting for nearly 13% of all medical claim costs, second only to the medical costs associated with sprain- and strain-related injuries (38% of all injuries). The majority of burns involved less than 1 day off of work. The head, hands, and other upper extremities were the body parts most frequently injured by burns or electric shocks. For this industry, electric-related burns accounted for the largest percentage of burn injuries, 399 injuries (45.8%), followed by thermal/heat burns, 345 injuries (39.6%), and chemical burns, 51 injuries (5.8%). These injuries also represented a disproportionate number of fatalities; of the 24 deaths recorded in the database, contact with electric current or with temperature extremes was the source of seven of the fatalities. High-risk occupations included welders, line workers, electricians, meter readers, mechanics, maintenance workers, and plant and equipment operators.

Trends in Occupational Electrical Fatalities in the U.S 1980-2010

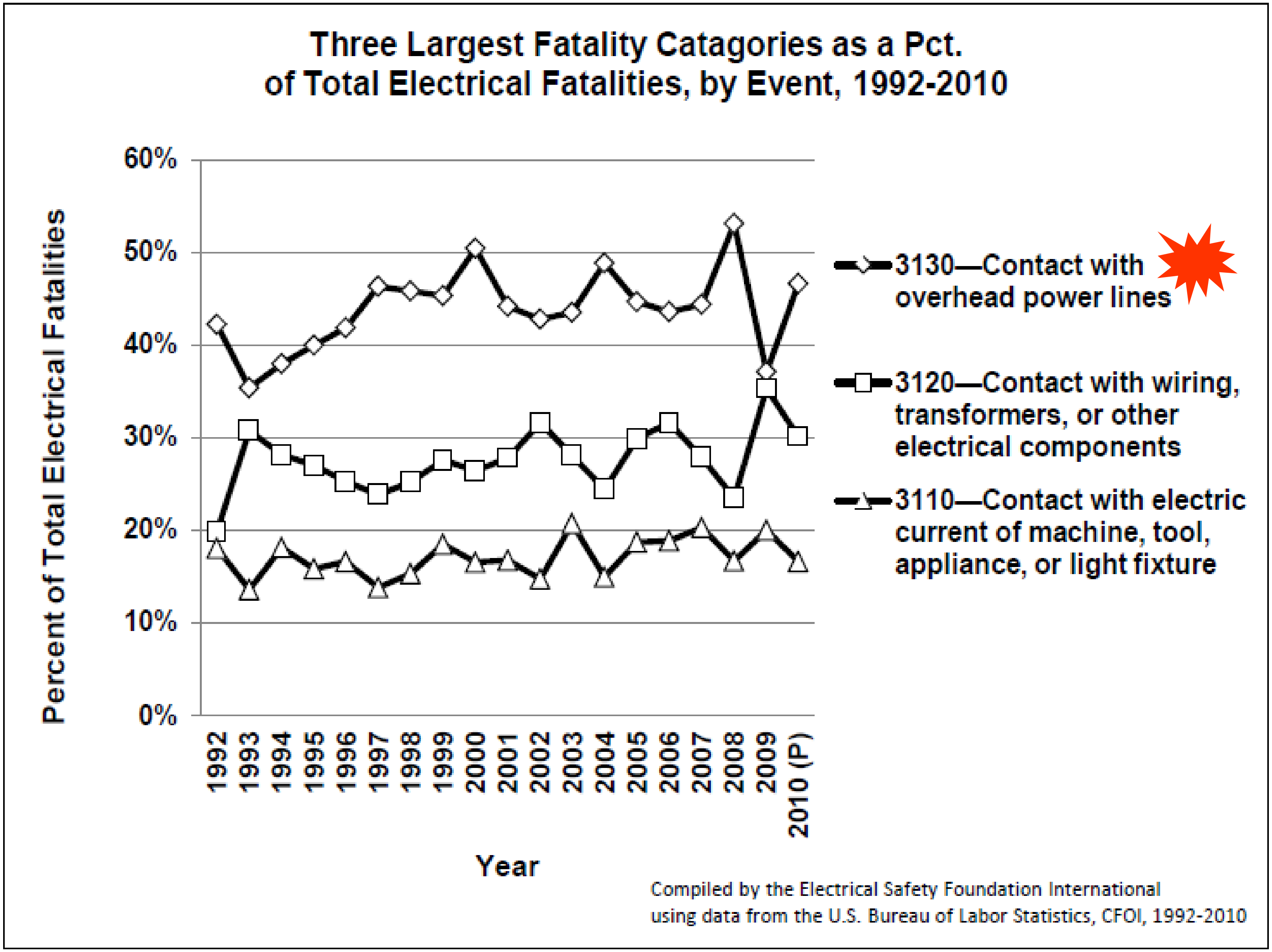


Casini, V., et al, *Worker Deaths by Electrocution*, National Institute for Occupational Safety and Health, publication no. 98-131, May 1998

Cawley, J.C., Brenner, B.C., *Occupational Electrical Injuries in the U.S., 2003-2009*, 2012 IEEE IAS Electrical Safety Workshop, January 30 – February 3, 2012, Daytona Beach, Florida



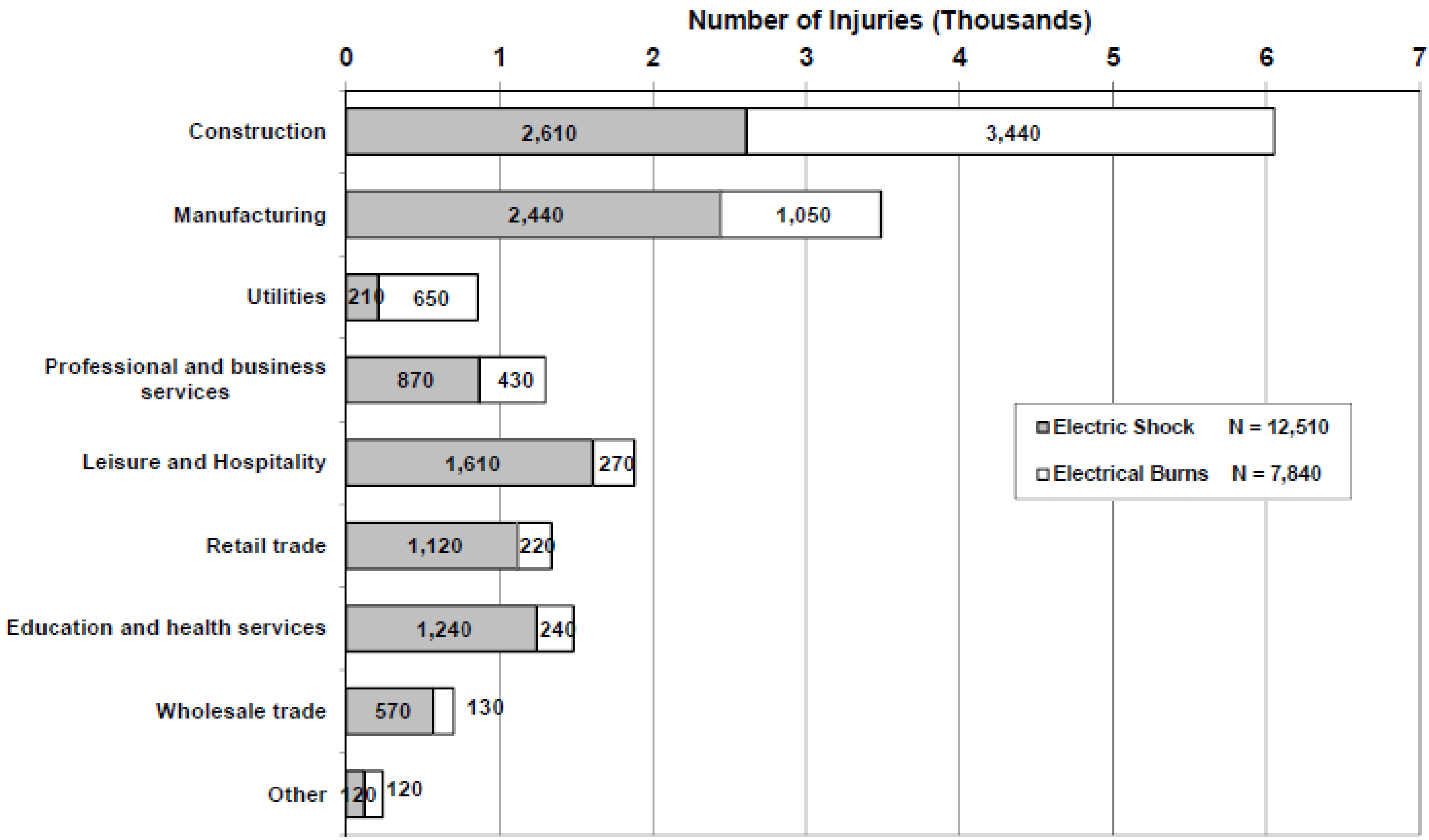
more than 70% reduction in electrical fatalities



Cawley, J.C., Brenner, B.C., *Occupational Electrical Injury Statistics for the US, 2003-2009*, Conference Record, 2012 IEEE IAS Electrical Safety Workshop, January 30-February 3, 2012, Daytona, FL

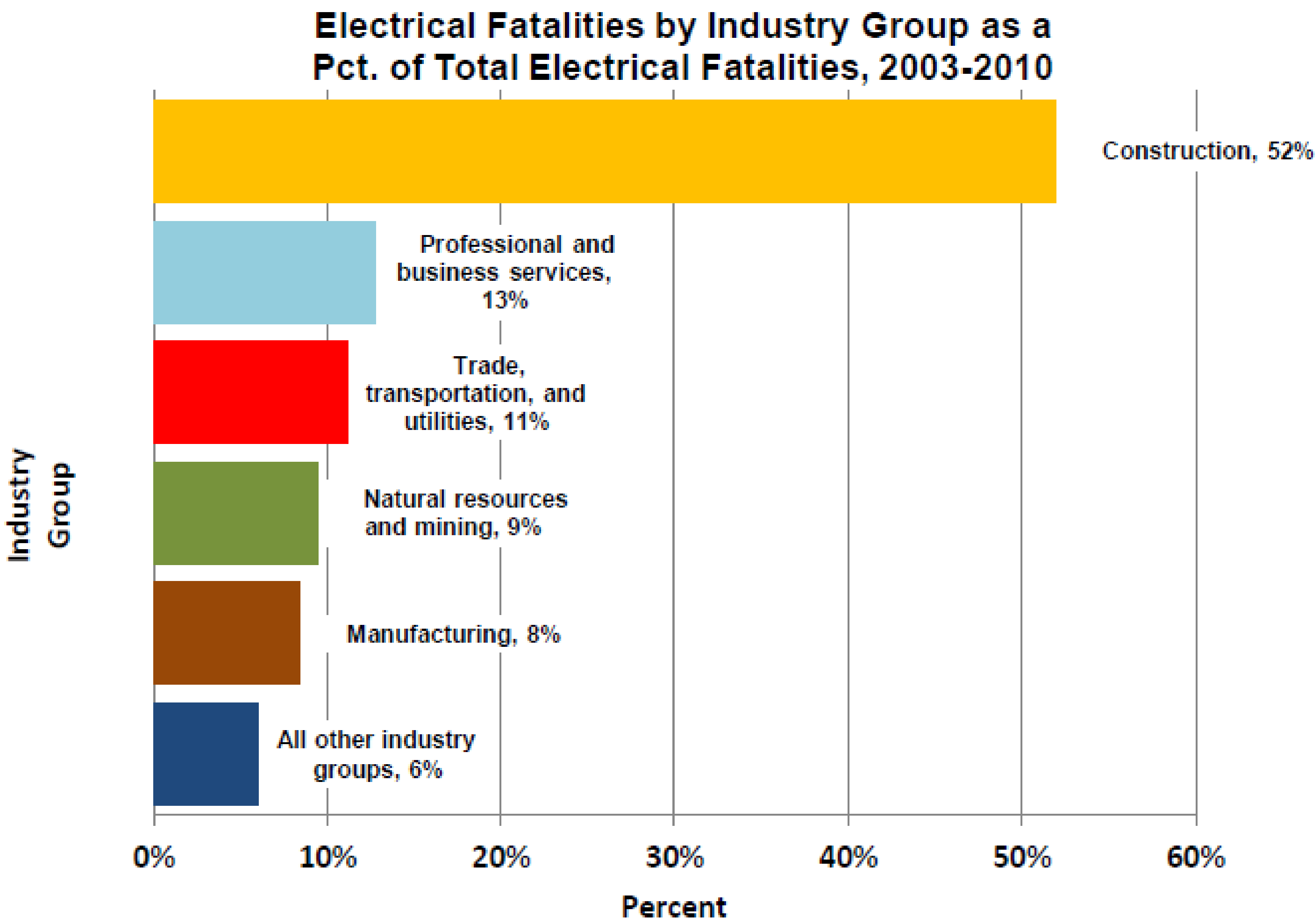
Injury Facts

Nonfatal Electrical Injuries, Private Industry, by Nature of Injury (Shocks, Burns), 2003-2010



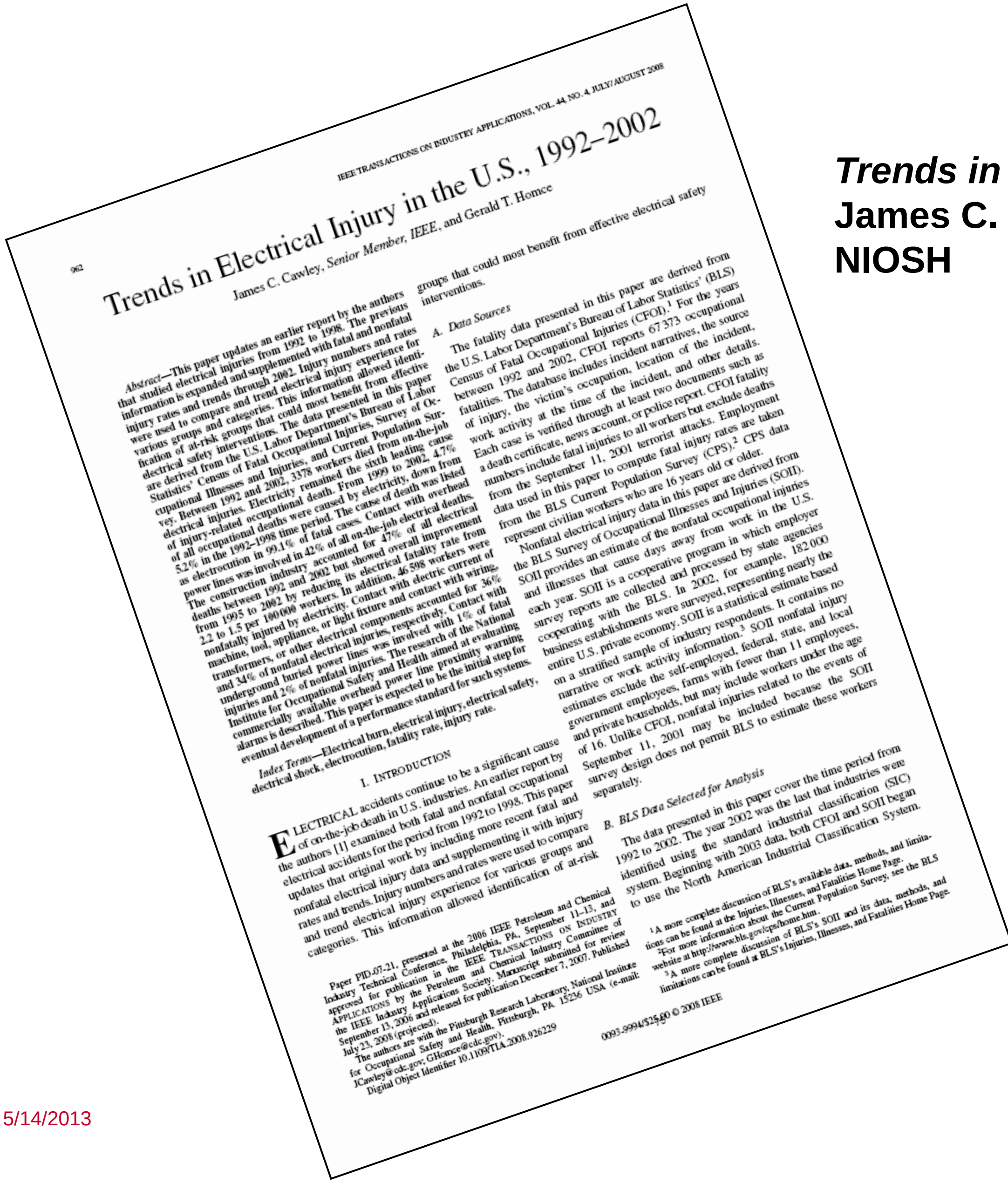
Compiled by the Electrical Safety Foundation International using data from the BLS SOII, 2003-2010

Injury Facts



Compiled by the Electrical Safety Foundation International
using data from the U.S. Bureau of Labor Statistics, CFOI, 1992-2010

Enabling Fact Based Decisions


IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 44, NO. 4, JULY/AUGUST 2008

Trends in Electrical Injury in the U.S., 1992–2002

James C. Cawley, Senior Member, IEEE, and Gerald T. Homce

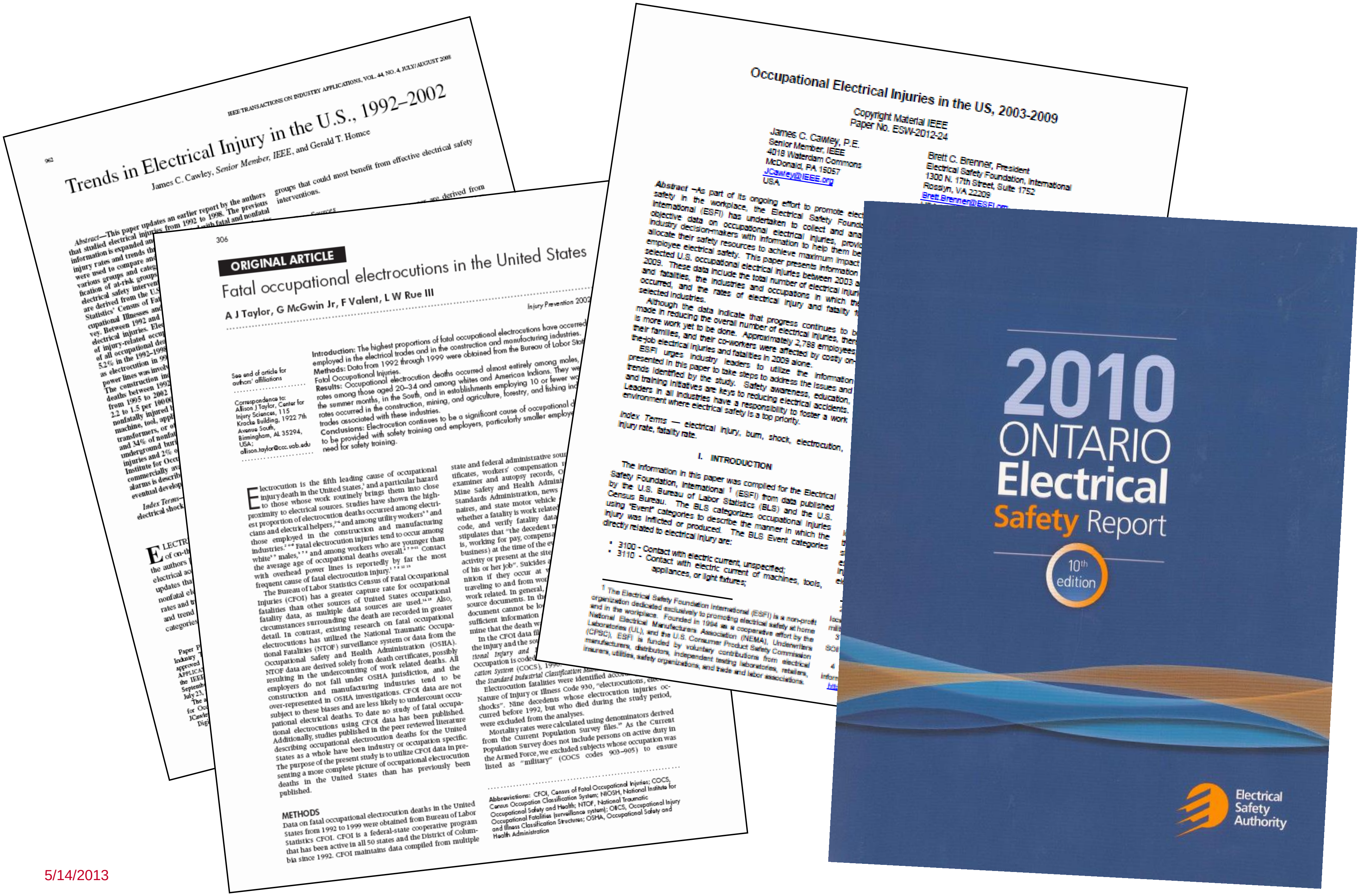
Trends in Electrical Injury in the US, 1992 – 2002

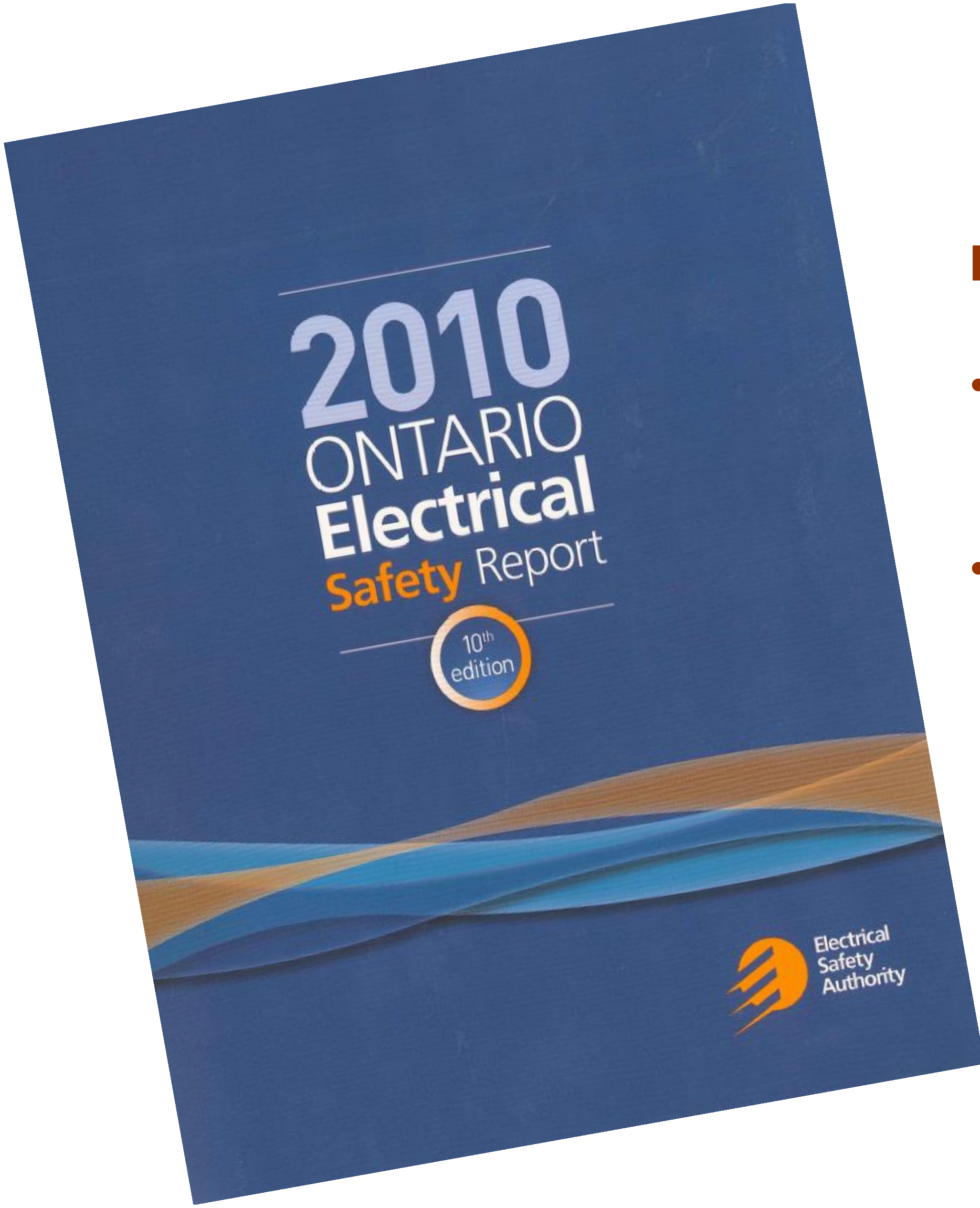
James C. Cawley and Gerald T. Homce

NIOSH

"Exposure to electrical energy is 6th leading cause of occupational fatality"

Credible Sources for Data on Electrical Injuries and Fatalities

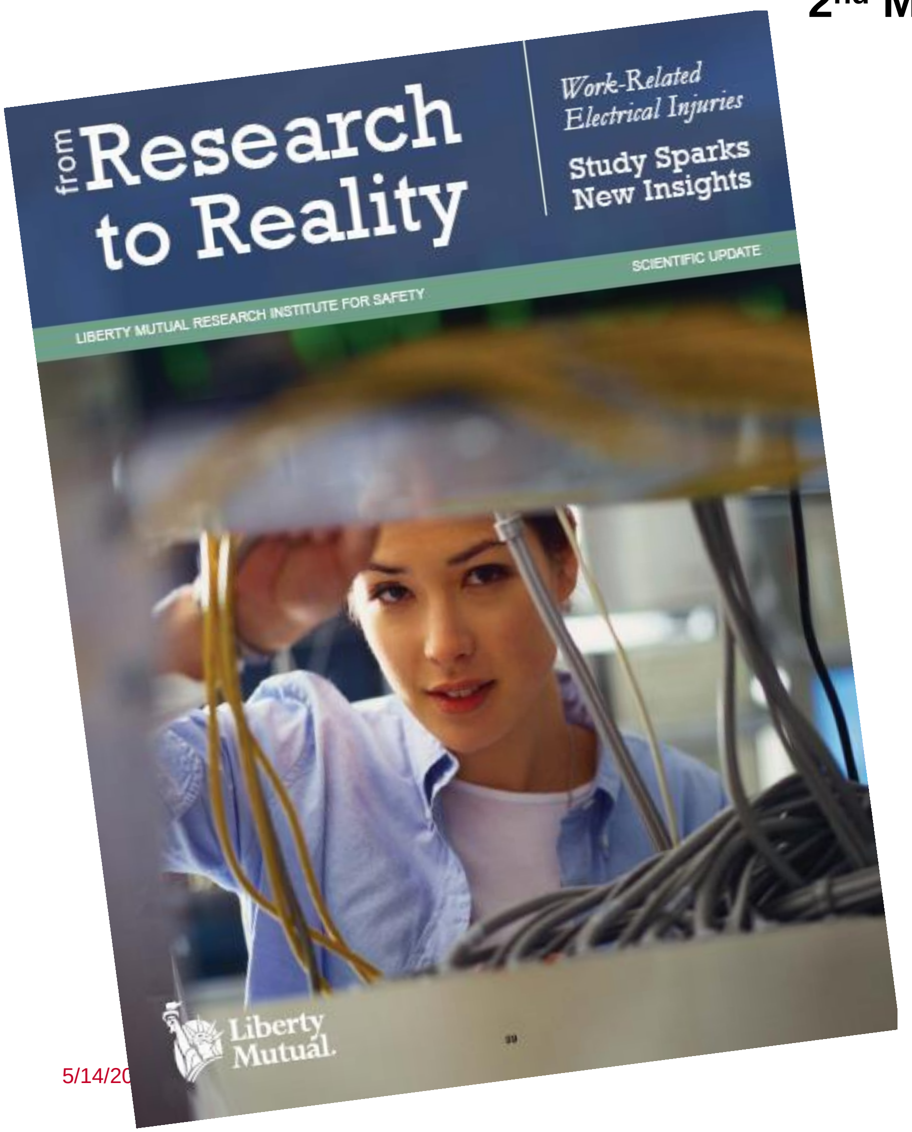




From 2001 to 2010

- **29% of workplace electrocutions involved electrical trades people**
- **71% were "other" workers**

Enabling Fact Based Decisions



Electrical Injuries are
2nd Most Costly Workers Comp Claim

Journal of Occupational and Environmental Hygiene, 6: 612–623
ISSN: 1545-9624 print / 1545-9632 online
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DOI: 10.1080/15459620903133683

Etiology of Work-Related Electrical Injuries: A Narrative Analysis of Workers' Compensation Claims

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[1]Liberty Mutual Research Institute for Safety, Center for Injury Epidemiology, Hopkinton, Massachusetts
[2]University of Maryland School of Medicine, National Study Center for Trauma and Emergency Medical Systems, Baltimore, Maryland

The purpose of this study was to provide new insight into the etiology of primarily nonfatal, work-related electrical injuries. We developed a multistage, case-selection algorithm to identify electrical-related injuries from workers' compensation claims and a customized coding taxonomy to identify pre-injury circumstances. Workers' compensation claims routinely collected over a 1-year period from a large U.S. insurance provider were used to identify electrical-related injuries using an algorithm that evaluated: coded injury cause information, nature of injury, "accident" description, and injury description narratives. Concurrently, a customized coding taxonomy for these narratives was developed to abstract the activity, source, initiating process, mechanism, vector, and voltage. Among the 586,567 reported claims during 2002, electrical-related injuries accounted for 1283 (0.22%) of nonfatal claims and 15 fatalities (1.2% of electrical). Most (72.3%) were male, average age of 36, working in services (33.4%), manufacturing (24.7%), retail trade (17.3%), and construction (7.2%). Body part(s) injured most often were the hands, fingers, or wrist (34.9%); multiple body parts/systems (25.0%); lower/upper arm; elbow; shoulder, and upper extremities (19.2%). The leading activities were conducting manual tasks (55.1%); working with machinery, appliances, or equipment; working with electrical wire; and operating powered or nonpowered hand tools. Primary injury sources were appliances and office equipment (24.4%); wires, cables/cords (18.0%); machines and other equipment (11.8%); fixtures, bulbs, and switches (10.4%); and lightning (4.3%). No vector was identified in 85% of cases. and the work process was initiated by others in less than 1% of cases. Injury narratives provide valuable information to overcome some of the limitations of precoded data, more specially for identifying additional injury cases and in supplementing traditional epidemiologic data for further understanding the etiology of work-related electrical injuries that may lead to further prevention opportunities.

[Supplemental materials are available for this article. Go to the publisher's online edition of the Journal of Occupational and Environmental Hygiene for the following free supplemental resource: tables detailing activity source by coding and BLS primary and secondary event coding for electrical injuries, a case selection algorithm of work-related electrical injuries, and a table detailing electrical injury narrative coding taxonomy.]

Keywords electrical, epidemiology, injury, narrative analysis, occupational

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INTRODUCTION

Electrocution is a leading cause of on-the-job fatalities in the United States,(1,2) and according to recent data from the U.S. Bureau of Labor Statistics (BLS), it accounted for an estimated 4% of all workplace fatalities in 2007.(3) When ranked by average years of life lost, work-related electrical fatalities are second only to traffic fatalities, leading to an estimated 41.1 years of potential life lost per case.(4) Reportedly, electrical injuries have higher average workers' compensation costs than all other recorded injuries except motor vehicle crashes.(5) Likewise, survey estimates from the BLS suggest that in 2005, there were 2950 nonfatal electrical incidents involving days away from work in private industry.(6)

There has been a marked decrease over the past century in the incidence of many fatal and nonfatal workplace injuries.(7) In general, this decrease can be attributed to strong government and private industry prevention efforts that included stronger safety regulations and increased dissemination of safety information. During the 1980s, for example, the prevention of electrocutions and electrical injury was a primary emphasis area of the National Institute for Occupational Safety and Health (NIOSH).(8)

In addition, mortality due to electrocution decreased more than any other cause of death to workers during this period potentially attributable to OSHA regulatory efforts, changes in National Electrical Codes, and safety awareness campaigns. More recently, trends in fatal electrical injuries have continued

Enabling Fact Based Decisions


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ORIGINAL ARTICLE

Fatal occupational electrocutions in the United States

A J Taylor, G McGwin Jr, F Valent, L W Rue III

Injury Prevention 2002;8:306–312

See end of article for authors' affiliations

Correspondence to: Allison J Taylor, Center for Injury Sciences, 115 Kracke Building, 1922 7th Avenue South, Birmingham, AL 35294, USA; allison.taylor@ccc.uab.edu

Introduction: The highest proportions of fatal occupational electrocutions have occurred among those employed in the electrical trades and in the construction and manufacturing industries.
Methods: Data from 1992 through 1999 were obtained from the Bureau of Labor Statistics Census of Fatal Occupational Injuries.
Results: Occupational electrocution deaths occurred almost entirely among males, with the highest rates among those aged 20–34 and among whites and American Indians. They were highest during the summer months, in the South, and in establishments employing 10 or fewer workers. The highest rates occurred in the construction, mining, and agriculture, forestry, and fishing industries and among trades associated with these industries.
Conclusions: Electrocution continues to be a significant cause of occupational death. Workers need to be provided with safety training and employers, particularly smaller employers, persuaded of the need for safety training.

Electrocution is the fifth leading cause of occupational injury death in the United States,[1] and a particular hazard to those whose work routinely brings them into close proximity to electrical sources. Studies have shown the highest proportion of electrocution deaths occurred among electricians and electrical helpers,[2-4] and among utility workers[5 6] and those employed in the construction and manufacturing industries.[2 4-6] Fatal electrocution injuries tend to occur among white[5 7] males,[5 7 8] and among workers who are younger than the average age of occupational deaths overall.[2 7 9-11] Contact with overhead power lines is reportedly by far the most frequent cause of fatal electrocution injury.[1 7 8 12 13]

The Bureau of Labor Statistics Census of Fatal Occupational Injuries (CFOI) has a greater capture rate for occupational fatalities than other sources of United States occupational fatality data, as multiple data sources are used.[14 15] Also, circumstances surrounding the death are recorded in greater detail. In contrast, existing research on fatal occupational electrocutions has utilized the National Traumatic Occupational Fatalities (NTOF) surveillance system or data from the Occupational Safety and Health Administration (OSHA). NTOF data are derived solely from death certificates, possibly resulting in the undercounting of work related deaths. All employers do not fall under OSHA jurisdiction, and the construction and manufacturing industries tend to be over-represented in OSHA investigations. CFOI data are not subject to these biases and are less likely to undercount occupational electrical deaths. To date no study of fatal occupational electrocutions using CFOI data has been published. Additionally, studies published in the peer reviewed literature describing occupational electrocution deaths for the United States as a whole have been industry or occupation specific. The purpose of the present study is to utilize CFOI data in presenting a more complete picture of occupational electrocution deaths in the United States than has previously been published.

METHODS

Data on fatal occupational electrocution deaths in the United States from 1992 to 1999 were obtained from Bureau of Labor Statistics CFOI. CFOI is a federal-state cooperative program that has been active in all 50 states and the District of Columbia since 1992. CFOI maintains data compiled from multiple state and federal administrative sources, including death certificates, workers' compensation reports, coroner, medical examiner and autopsy records, OSHA fatality reports, the Mine Safety and Health Administration, the Employment Standards Administration, news media, follow up questionnaires, and state motor vehicle crash reports. To determine whether a fatality is work related, state personnel who collect, code, and verify fatality data use a case definition that stipulates that "the decedent must have been employed (that is, working for pay, compensation, or profit or in the family business) at the time of the event and engaged in a legal work activity or present at the site of the incident as a requirement of his or her job". Suicides and homicides meet the case definition if they occur at work. Fatalities that occur while traveling to and from work (commuting) are not considered work related. In general, each death must be verified by two source documents. In those instances where a second source document cannot be located, the fatality is included only if sufficient information exists from the first source to determine that the death was work related.

In the CFOI data files, the event or exposure that produced the injury and the source of injury are coded using the *Occupational Injury and Illness Classification Structures* (OIICS).[16] Occupation is coded according to the *Census Occupation Classification System* (COCS), 1990.[17] Industry is coded according to the *Standard Industrial Classification Manual*, 1987 edition.[18]

Electrocution fatalities were identified according to OIICS Nature of Injury or Illness Code 930, "electrocutions, electric shocks". Nine decedents whose electrocution injuries occurred before 1992, but who died during the study period, were excluded from the analyses.

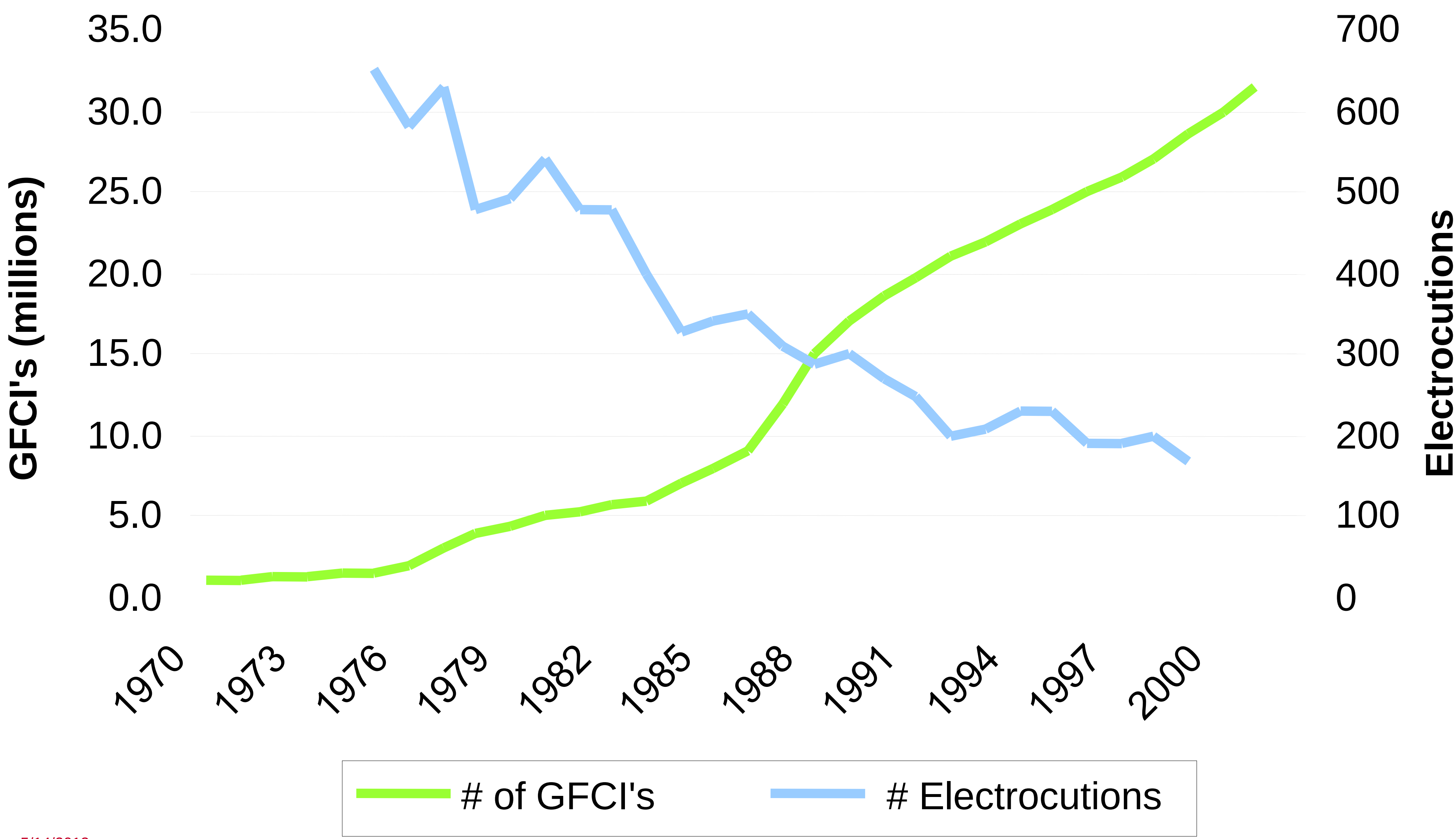
Mortality rates were calculated using denominators derived from the Current Population Survey files.[19] As the Current Population Survey does not include persons on active duty in the Armed Force, we excluded subjects whose occupation was listed as "military" (COCS codes 903–905) to ensure

Abbreviations: CFOI, Census of Fatal Occupational Injuries; COCS, Census Occupation Classification System; NIOSH, National Institute for Occupational Safety and Health; NTOF, National Traumatic Occupational Fatalities (surveillance system); OIICS, Occupational Injury and Illness Classification Structures; OSHA, Occupational Safety and Health Administration

Fatal Occupational Electrocutions in the United States
A. J. Taylor, G. McGwin Jr., F. Valent and L.W. Rue

Includes in depth analysis of fatalities by workplace scenarios

GFCI Impact on Electrocutions Associated with Consumer Products



A hazard for all workers – not just electrical workers

Top Occupations having Most Electrocution Deaths in U.S

- Electricians & Linemen
- Construction laborers
- Managers
- Truck drivers
- Agricultural workers
- Roofers
- Painters
- Carpenters
- Landscapers and groundskeepers

~1/2 of electrocution fatalities are "other" workers

Electrical workers

Electrical Fatalities in DuPont

1968 - 2011

7 out of 12 were not in electrical crafts

- Painter
- Carpenter (2)
- Welder
- Window washer
- Engineering consultant *
- Construction supervisor *
- Coal handling supervisor
- Electrician (3) *
- Sales representative

Other workers


200A
DANGER
MAIN ONLY

Chicago Tribune
Breaking News, Since 1847

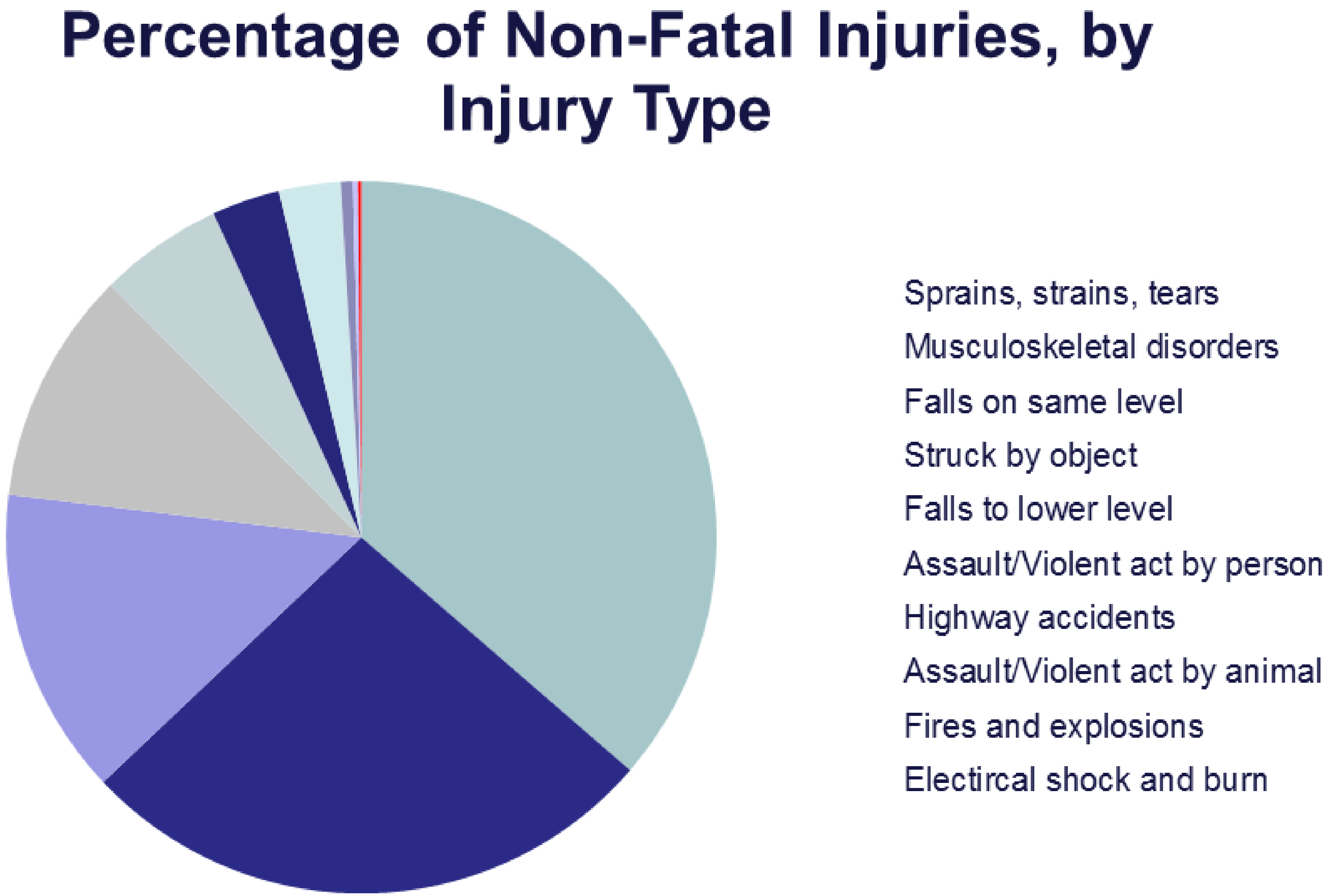
Teens die after detasseling electrocution

OSHA officials investigate field accident

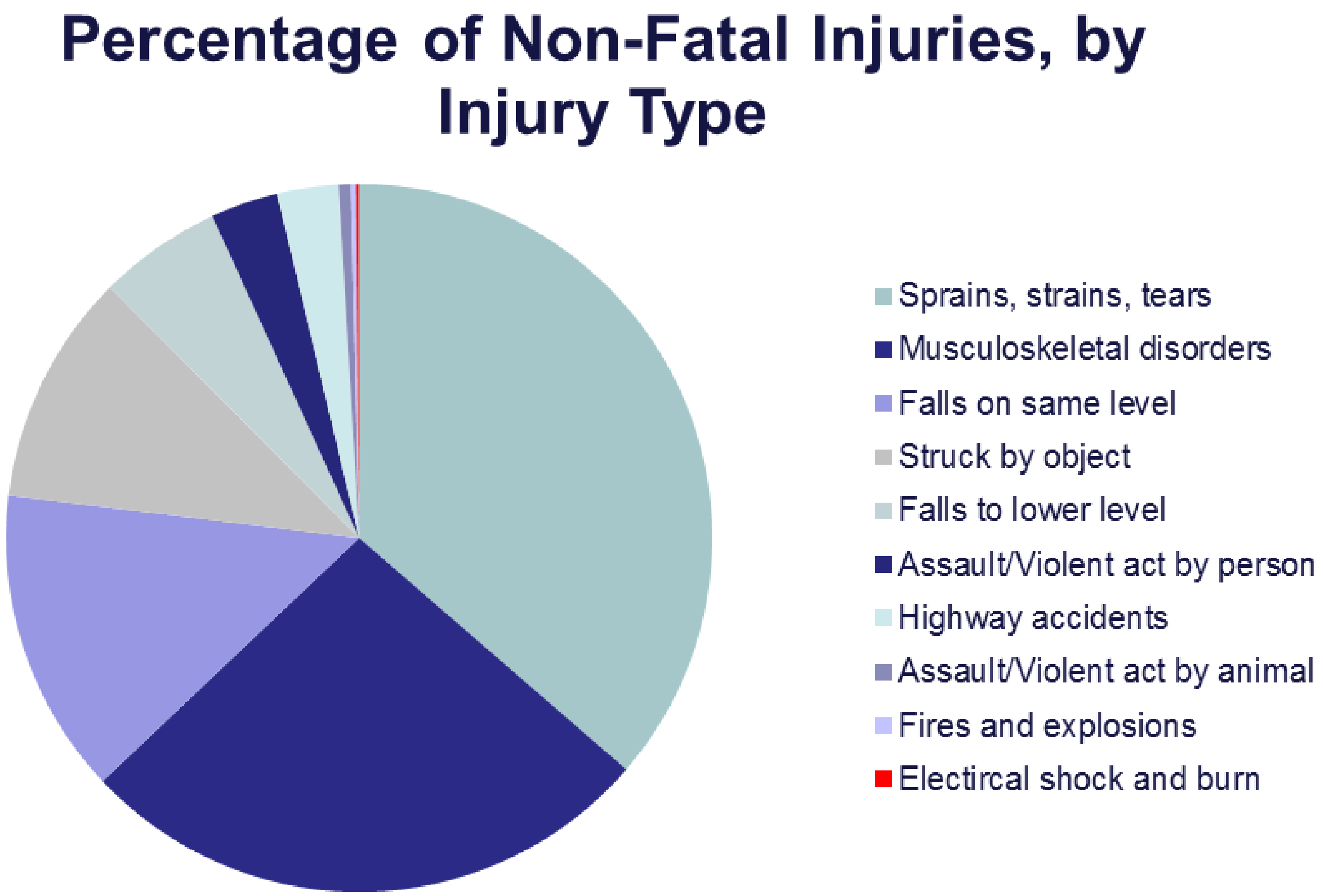
July 27, 2011 | By Erin Meyer and George Knue, Tribune reporters

Hannah Kendall and Jade Garza were working in the farm fields around their northwestern Illinois home over the summer, earning a few bucks before starting their freshman year at Sterling High School.

Hannah's Facebook page featured a photo of the two smiling girls embossed with the message, "Jade Garza is my bestest friend in the whole world … and that is never going to change."

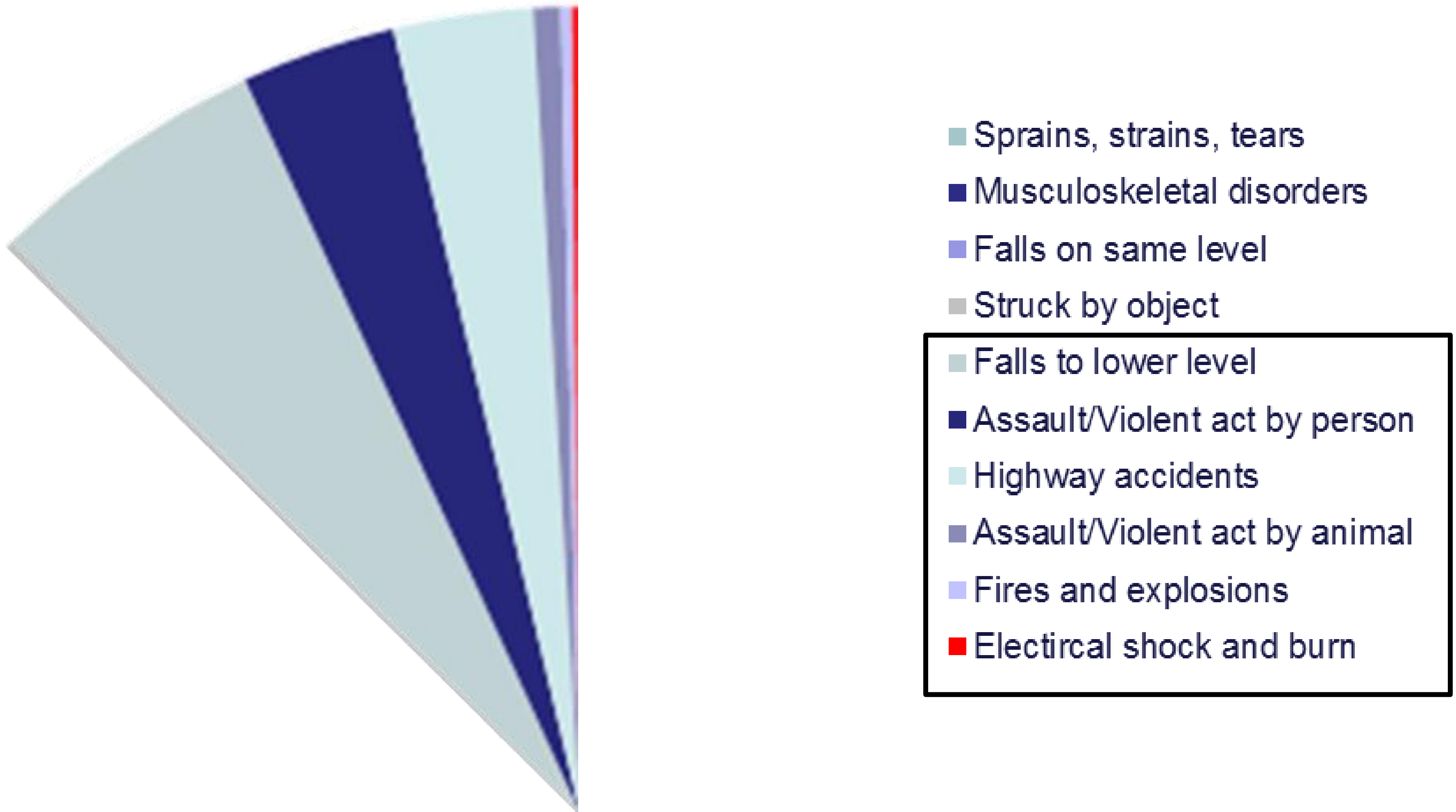


Lost Time Injuries in the U.S. 2010 BLS Data



Lost Time Injuries in the U.S. 2010 BLS Data

Percentage of Non-Fatal Injuries, by Injury Type



Lost Time Injuries in the U.S. 2010 BLS Data

Frequency ≠ Severity (US OSHA Data)

Event or Exposure	No. Fatalities 2010
Total	4547
Transportation. *excludes water, rail, air*	1519
Assaults and violent acts	808
Falls	635
Struck by object or equipment	402
Caught in or compressed by equipment	224
Exposure to harmful substance or environment	246
2 → Contact with electric current	163
Aircraft	151
Caught in or crushed by collapsing materials	91
Water vehicle	52
Explosions	78
Railway	44
Other	134

Figure 1 Occupational Fatalities by cause in the US 2010 (US Bureau of Labor Statistics)

Event or Exposure	No. 2010
Total	1,191,100
Sprains, strains, tears	474,000
Musculoskeletal disorders	346,300
Falls on same level	182,400
Struck by object	138,530
Falls to lower level	73,520
Assault/Violent act by person	40,310
Highway accidents	36,460
Assault/Violent act by animal	7,160
Fires and explosions	3000
1 → Electrical shock and burn	1890

Figure 2 Comparison of select Non-fatal Occupational Lost Time Injuries in the U.S 2010 (U.S. Bureau of Labor Statistics Economic News Release, 2010)

Event or Exposure	LTI / Fatality Ratio*
Fires & Explosions	12
3 → Contact with electricity	13
Transportation accidents	23
Assaults & violent acts	28
Fall to a lower level	104
Exposure to harmful substance or environment	107
Caught in, compressed or crushed	134
Struck by object	323
Falls on same level	2056
Struck against object	8414
Slips or trips without fall	12593
Overexertion in lifting	14033

Figure 3 Data from US Bureau of Labor Statistics showing ratio of Lost Time Injuries to Fatalities. Adapted from Anderson and Dnkl, 2007 with electrical injury data from Cawley and Brenner, 2010 .

Conclusions:

1. Sprains, strains, tears and MSDs accounted for 69% of all non-fatal Lost Time Injuries (LTIs), but have low risk for fatality.

2. Hazards that account for 9.6% of non-fatal LTIs are hazards with highest potential for fatality. (Fires & explosions, contact with electricity, highway accidents, falls to lower level.)

Low Frequency – but HIGH Consequences

Low Frequency

- **0.16% of Lost Time Injuries are from electrical contact[1]**
- **3.6% of occupational fatalities[1]**

High Consequence

- **7th leading cause of occupational fatality[1]**
- **1-2% of total injuries, but 28-52% of total medical costs[2]**

  (study of one utility)
- **2nd most costly workers comp claim[3]**

[1] Cawley, J.C., Brenner, B.C., *Occupational Electrical Injury Statistics for the US, 2003-2009*, Conference Record, 2012 IEEE IAS Electrical Safety Workshop, January 30-February 3, 2012, Daytona, FL

[2] Wyzka, R and Lindroos, W., "Health Implications of Global Electrification", *Annals of the New York Academy of Sciences*, vol 888, October30, 1999, pp 1-7

[3] "Work Related Electrical Injuries', *From Research to Reality*, Liberty Mutual Research Foundation, Winter 2010.

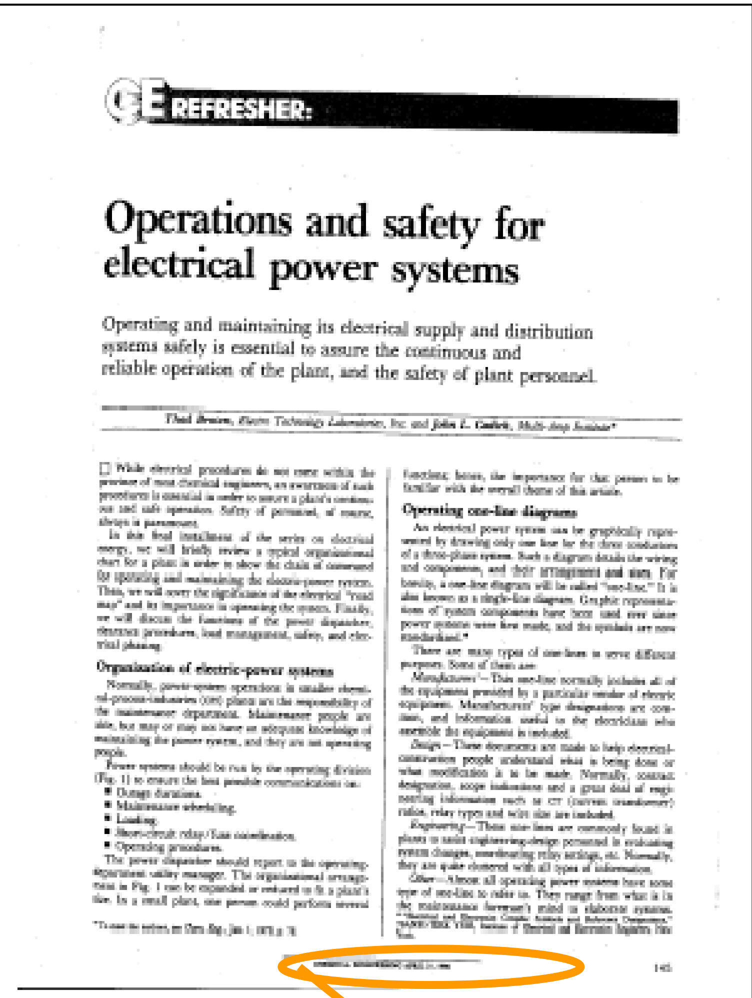
Summary

1. **Electrical injuries are low frequency, but very high consequence**
2. **Absence of injury history does not mean there is an effective electrical safety program in place**
3. **½ of the electrical fatalities are not electricians and linemen**

Standards

- **Role, Limitations and upcoming changes**
- **Prevention through Design**
- **Maintenance & Reliability**
- **Safety Management Systems**

33 Years Ago



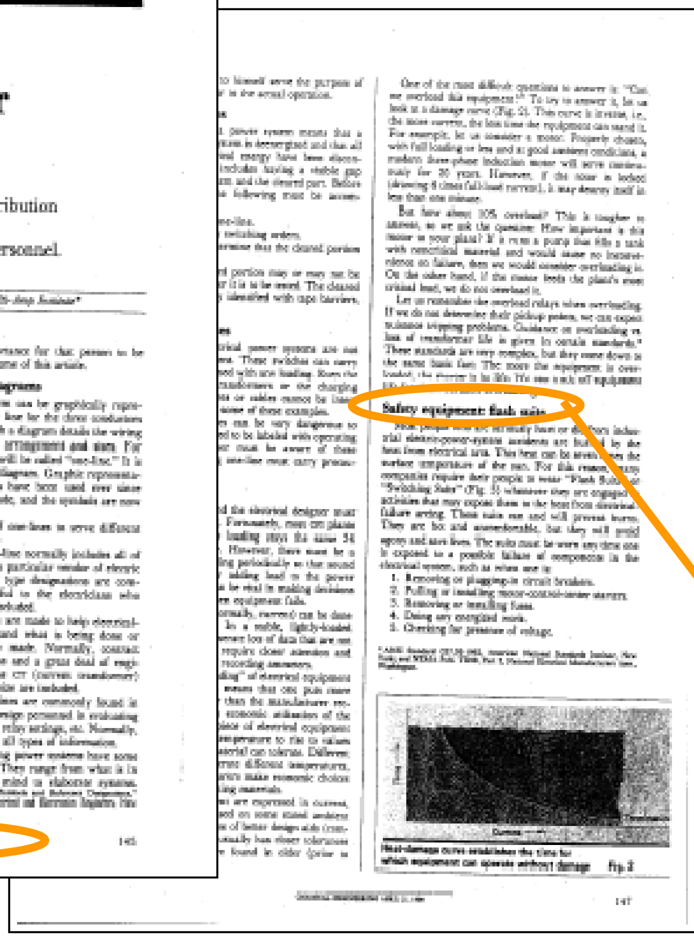
CE REFRESHER:

Operations and safety for electrical power systems

Operating and maintaining its electrical supply and distribution systems safely is essential to assure the continuous and reliable operation of the plant, and the safety of plant personnel.

Operating one-line diagrams

Organization of electric-power systems



Safety equipment: flash suits

CE REFRESHER

Safety equipment: energy detectors

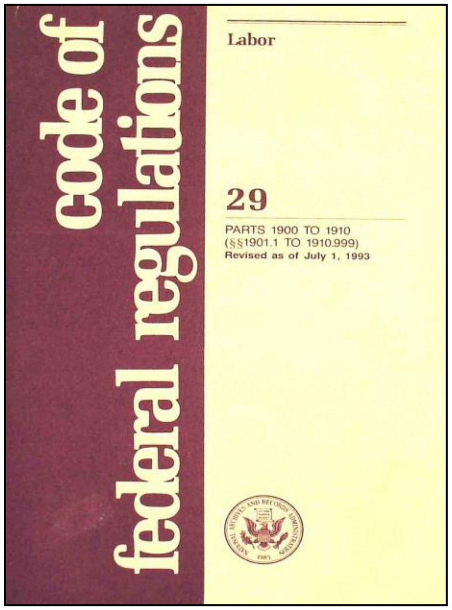
Safety equipment: rubber gloves

Arc Flash Protective Clothing

Chemical Engineering, April 21, 1980

Regulatory requirements

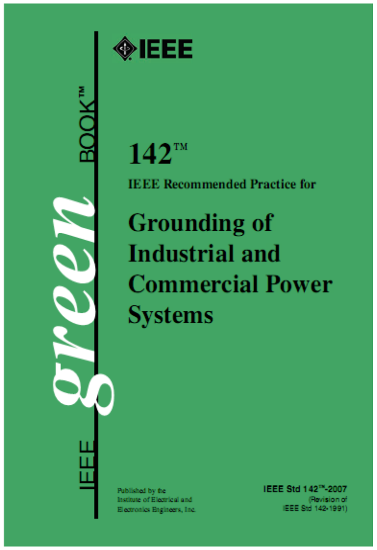
- Provide a safe workplace
- Assess the workplace for hazards
- Eliminate or mitigate the risks



OSHA Regulations

- General Duty Clause
- 1910 subpart S, safety related electrical work practices
- 1910.132 Personal protective equipment for general industry
- 1910.269 Electric power generation, transmission and distribution
- 1910.335 Safeguards for personnel protection

Industry consensus codes, standards and guidelines provide up to date methods



IEEE 142

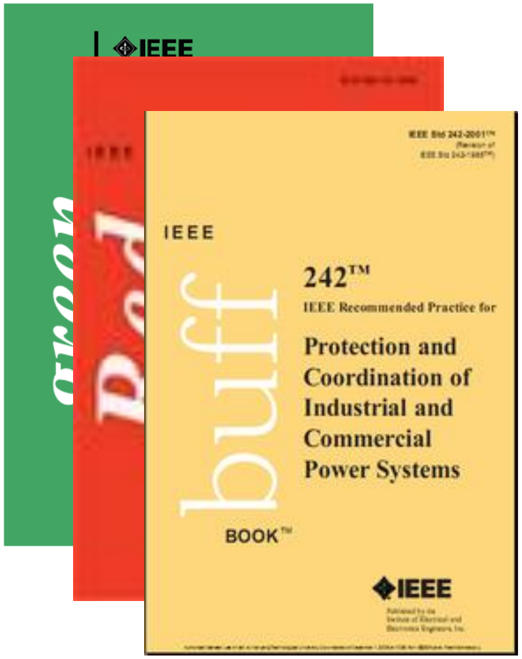
Recommended Practice for Grounding and Bonding of Industrial and Commercial Power Systems

Industry consensus codes, standards and guidelines provide up to date methods

IEEE 141

Recommended Practice for Electric Power Distribution for Industrial Plants

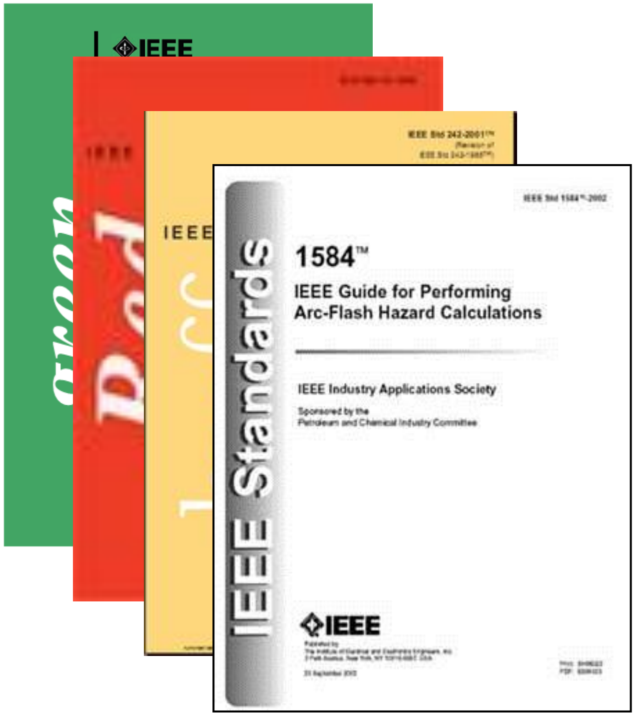
Industry consensus codes, standards and guidelines provide up to date methods



IEEE 242

Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

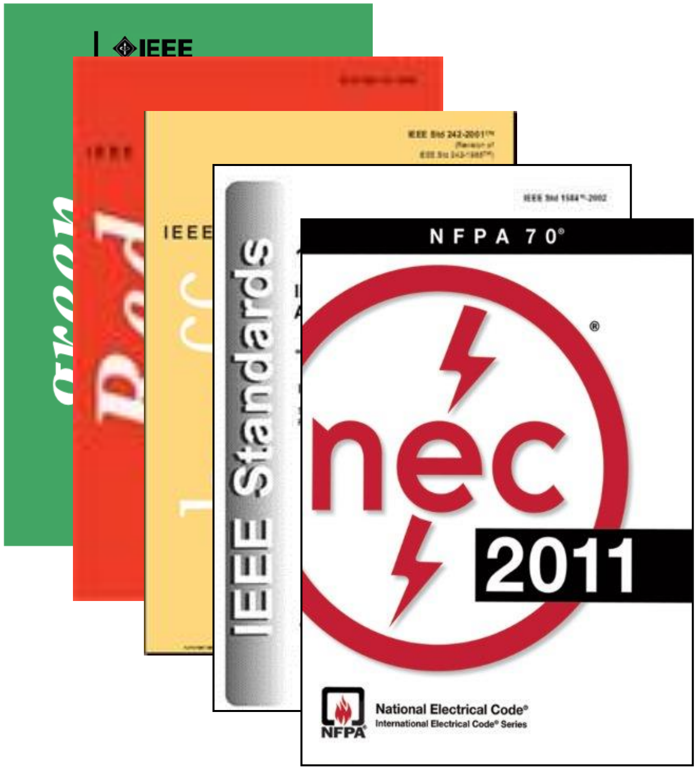
Industry consensus codes, standards and guidelines provide up to date methods



IEEE 1584

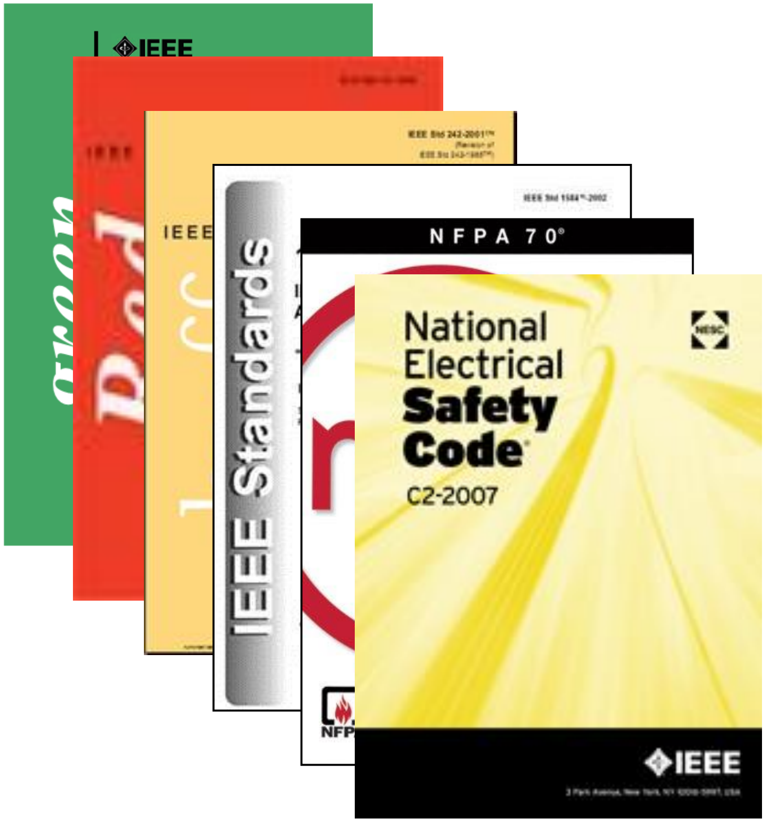
Guide for Performing Arc Flash Hazard Calculations

Industry consensus codes, standards and guidelines provide up to date methods



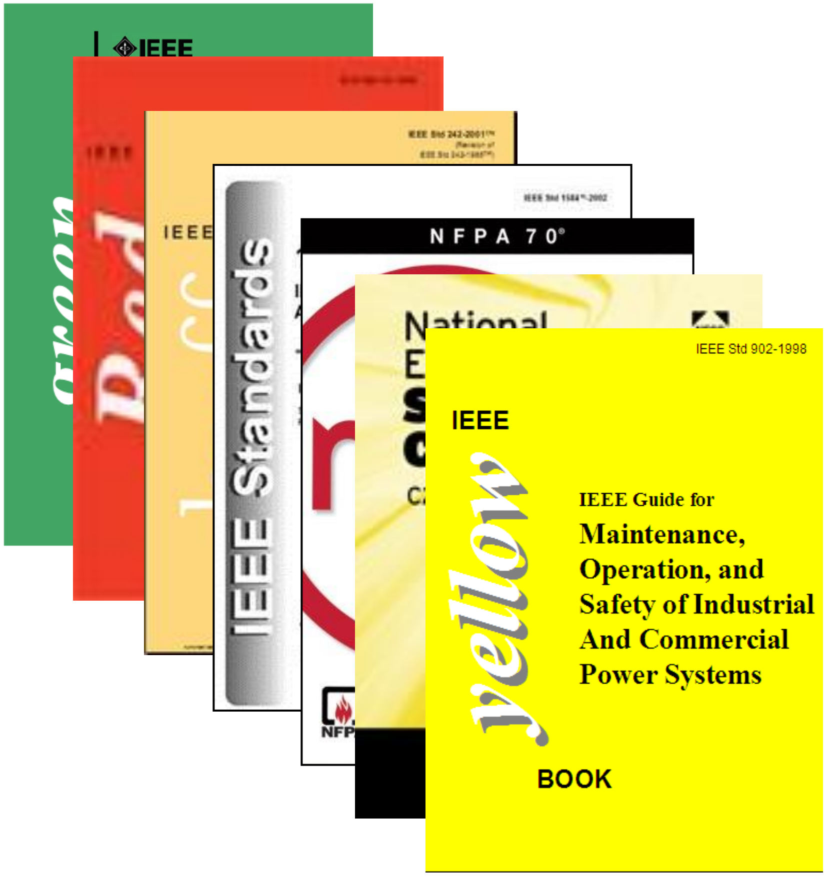
NFPA 70
National Electrical Code

Industry consensus codes, standards and guidelines provide up to date methods



IEEE/ANSI C2
National Electrical Safety Code

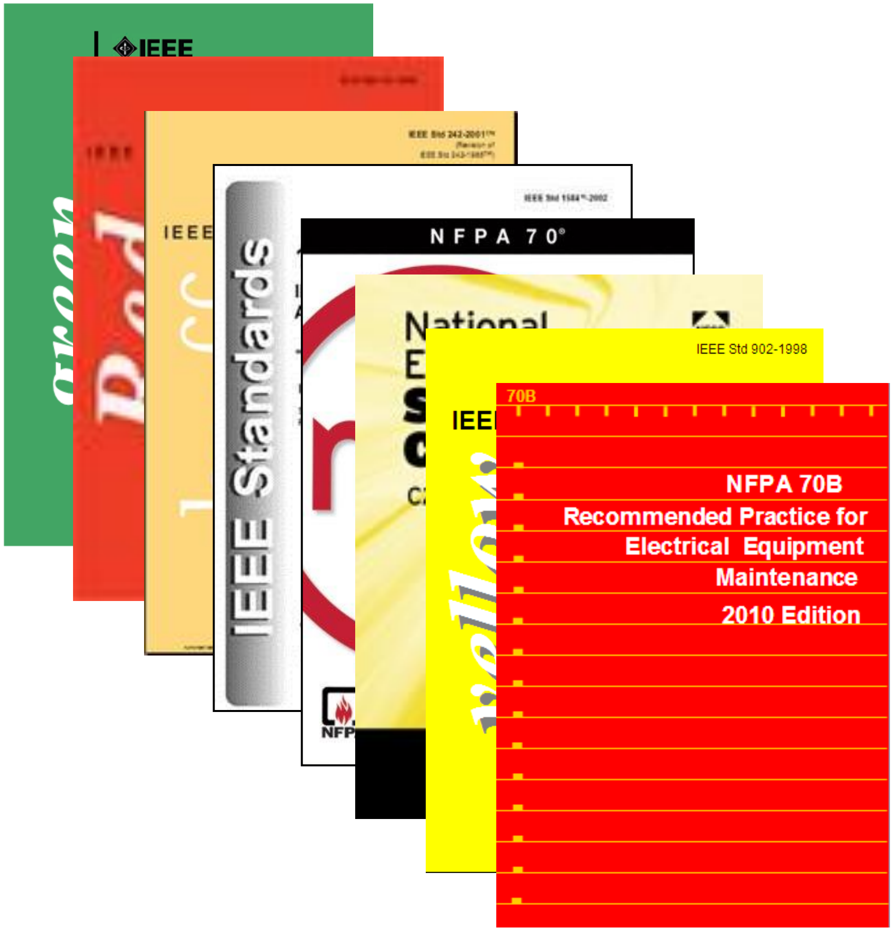
Industry consensus codes, standards and guidelines provide up to date methods



IEEE 902

Guide for Maintenance, Operation and Safety of Industrial and Commercial Power Systems

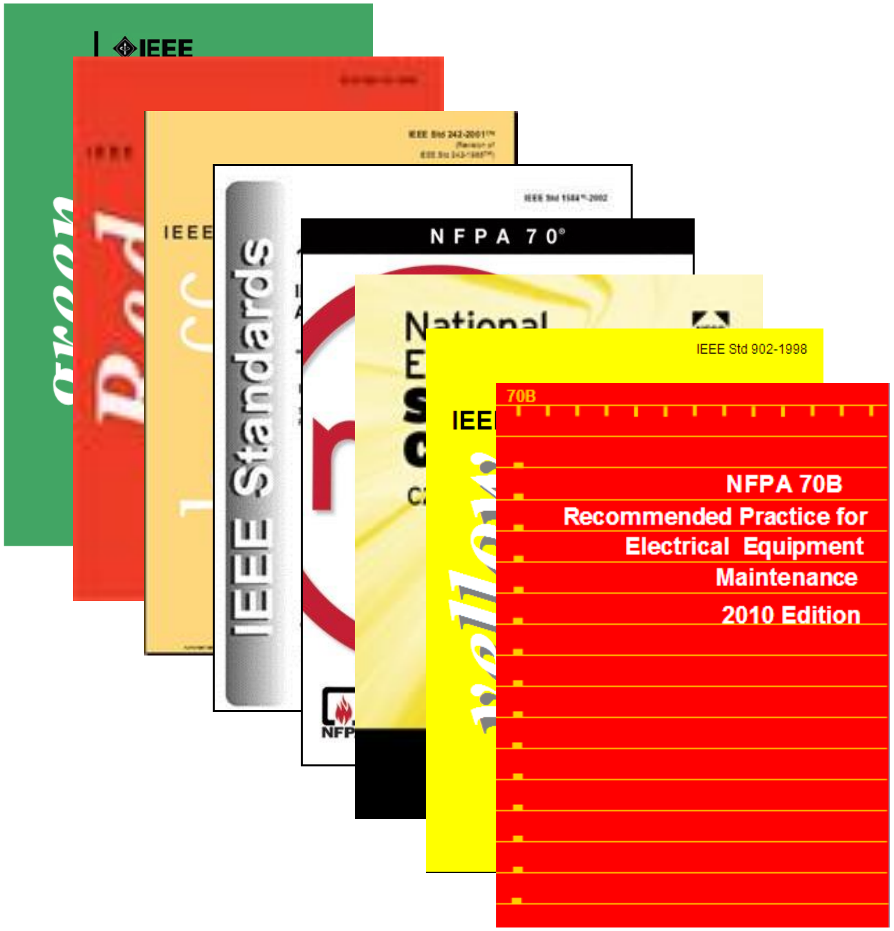
Industry consensus codes, standards and guidelines provide up to date methods



NFPA 70B

Recommended Practice for Electrical Equipment Maintenance

Industry consensus codes, standards and guidelines provide up to date methods



MAKE WAY FOR Z463

CSA's new guideline for electrical system maintenance

Based on the maintenance requirements in the Canadian Standard's Association's CSA Z462 Workplace Electrical Safety Standard and the Canadian Electrical Code, work is underway to develop a general guideline on best practices for maintenance of electrical-powered equipment, power distribution systems, and control devices. To be designated CSA Z463, this new guideline will bridge the gap between safe equipment design and installation (addressed in the Electrical Code) and safe maintenance work practices (addressed in CSA Z462).

This new CSA Guideline will focus on principles of predictability, expected failure modes, and pre-emptive scheduled maintenance to avoid extensive downtime, and maintain a state of readiness for critical equipment. It will be of particular interest to small and medium-sized organizations that do not have established maintenance programs in place.

This new guidance document is being developed through CSA's consensus process by the relevant Technical Committee. This committee is composed of representatives drawn from both our Electrical Standards and Occupational Health & Safety Standards Programs. Members were selected based on their representation of key stakeholder groups from across Canada, and others who supply electrical equipment and services to Canadian industrial and commercial workplaces.

In the near future, each Working Group (WG) from the Technical Committee will refer their drafts to CSA's Definitions Group to ensure consistent use of technical terms in both the guidelines and other CSA documents. In addition, each WG is putting together a list of supporting information for consideration for entry to the Annex.

Although Z463 will be a general guideline, applicable to most types of electrical systems used in industrial and commercial operations, it will focus on maintenance of common electrical systems critical to safety functions and protection of facilities. The guideline will also feature a section on maintenance of special equipment and life-critical systems.

Z463 will be a voluntary best practices guideline for use anywhere in Canada and will contain links to resource material especially useful to small and medium-sized organizations. As such, CSA hopes that Z463 will be used as a resource document by companies, institutions, and contractors as a basis for their preventive maintenance programs.

CSA Z463 is still looking for technical members with a focus on the regulatory and commercial or institutional sectors. The CSA Z463 committee is scheduled to meet in June to discuss the guideline in Quebec City.

Look for your opportunity to review the draft of the Z463 Guideline towards the end of 2012 on CSA's Public Review web site: www.review.csa.ca. CSA plans to publish this guidance document in mid-2013. ▪

- Dave Shanahan, Canadian Standards Association

Z462 & EQUIPMENT MAINTENANCE

Get familiar with Annex B

While you are waiting for the Z463 to be released, stay safe with the safety practices found in CSA's electrical safety in the workplace standard, Z462. Annex B, specifically, highlights safety-related electrical maintenance practices on what is considered appropriate maintenance on critical electrical distribution equipment, circuit breakers and other protective devices so that arc flash hazards can be prevented.

Arcing faults and arc flashes occur when abnormalities exist in live electrical equipment. These abnormalities result due to lack of maintenance, aging and other factors. When an electrical worker attempts to de-energize, diagnose, or troubleshoot problems, gaps between energized conductors and circuit parts can become compromised, not to mention that mechanical parts can malfunction, thus increasing the probability of an arc flash and release of incident energy.

Annex B highlights:

- Risk categories and maintenance justification
- Reliability centered maintenance (RCM)
- Frequency of Maintenance tests
- Maintaining electrical drawings
- Maintenance standards

Proper training is a must. The Electricity Forum is currently offering updated CSA Z462 training with Annex B as a part of its focus. Find out more information at www.electrical-training.net.

Industry consensus codes, standards and guidelines provide up to date methods

ANSI/NETA MTS-2007
Standard for Maintenance Testing Specifications

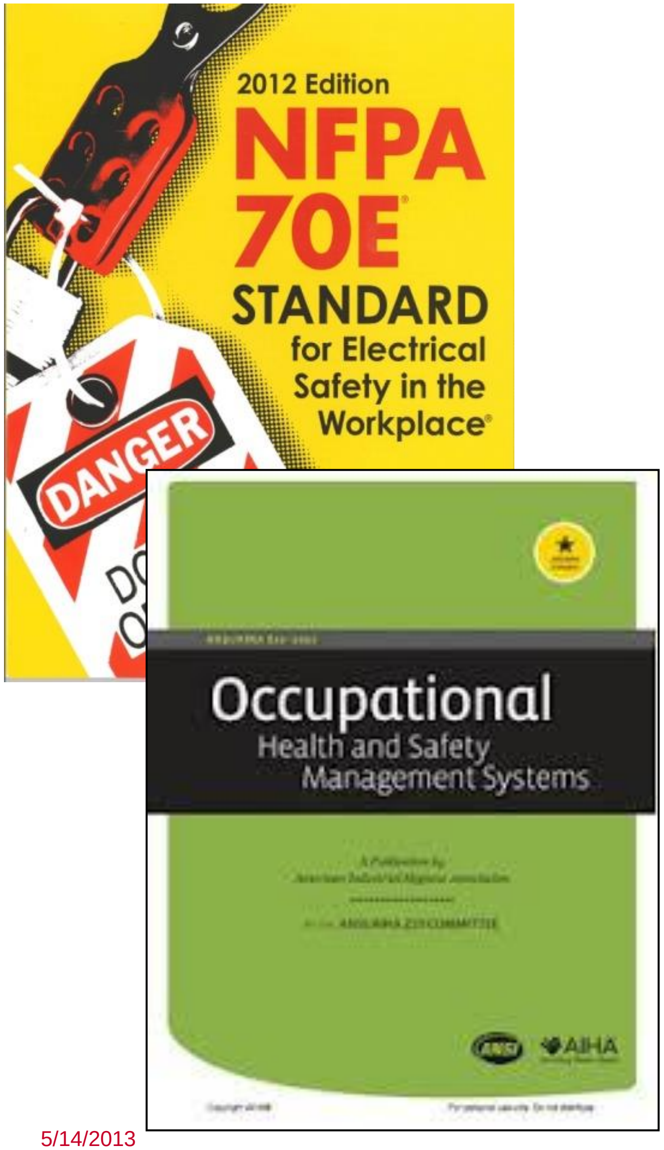
Industry consensus codes, standards and guidelines provide up to date methods

NFPA 70E and CSA Z462

Industry consensus codes, standards and guidelines provide up to date methods

- Inherently safer design
- Arc hazard analysis
- Installation methods
- Error free operation
- Warnings and labels
- Maintenance & reliability
- Administrative controls
- Safe work practices
- Personal protective equipment

Linking to Safety Management Systems

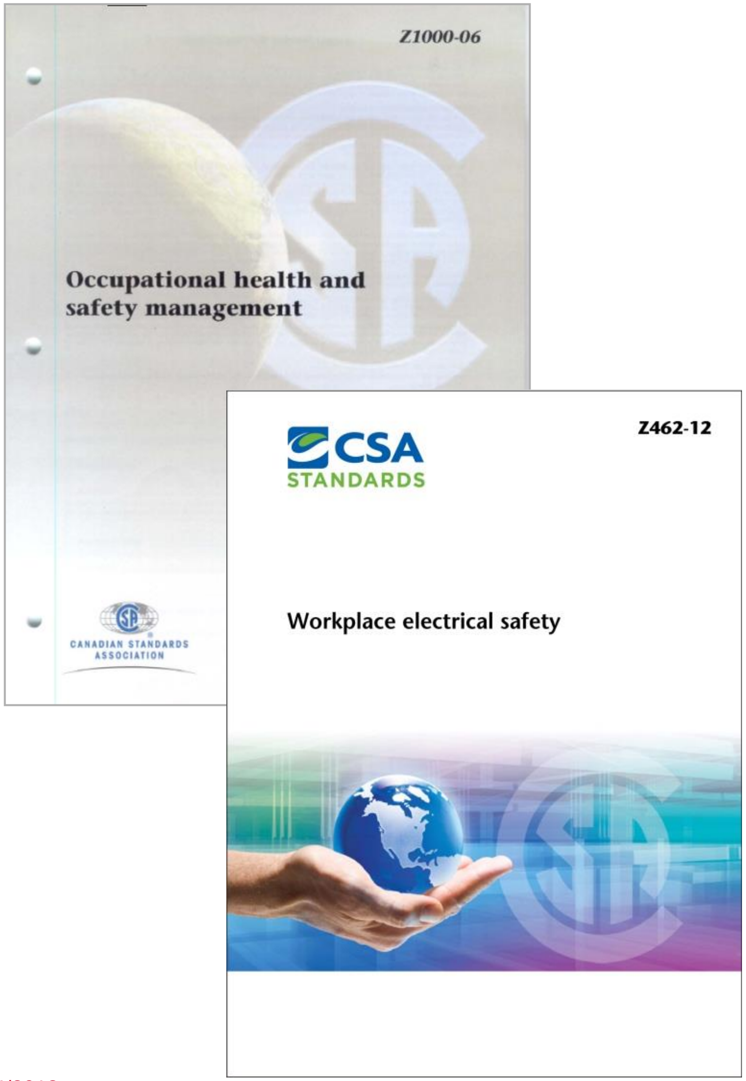


110.7 Electrical Safety Program

FPN 1: Safety–related work practices are just <u>one component</u> of an overall electric al safety program

FPN No. 2: ANSI/AIHA Z10-2012, *American National Standard for Occupational Health and Safety Management Systems*, provides a framework for establishing a comprehensive electrical safety program as a component of an employer's occupational safety and health program.

Linking to Safety Management Systems



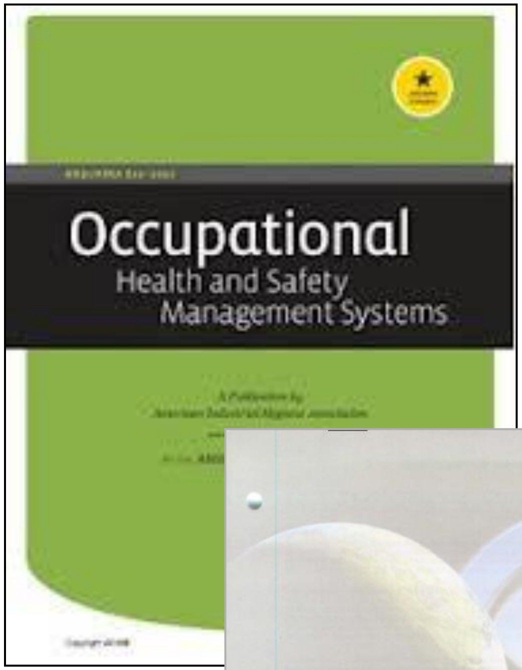
Notes:

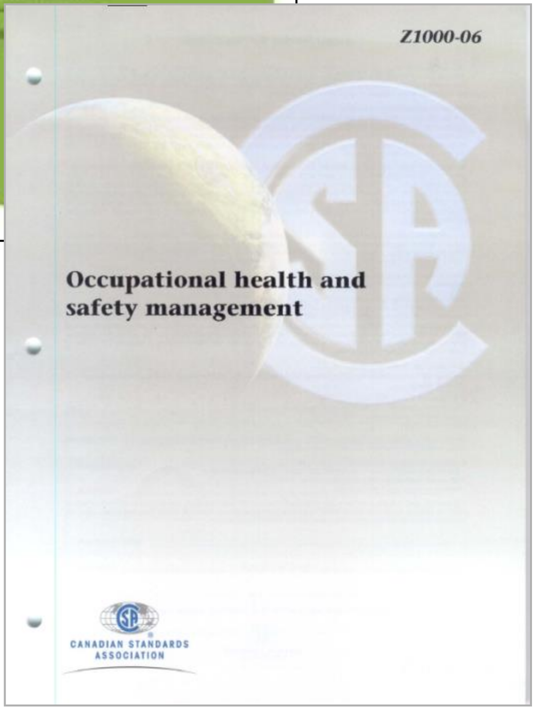
(1) Safety–related work practices are just one component of an overall electrical safety program

(2) Effective application of the requirements of this standard can be best achieved within the framework of a recognized occupational health and safety managed system. Annex A provides information on applying the requirements of this Standard within the frame work of the occupational safety and health management system.

(3) CAN/CSA-Z1000, provides a framework for establishing a comprehensive electrical safety program as a component of an employer's occupational safety and health system.

ANSI Z10 & CSA Z1000





- Standard for a safety & health management system
- Uses the Deming quality management model
- Comprehensive hazard control measures for prevention & protection
- A management roadmap for continuous improvement and sustainability

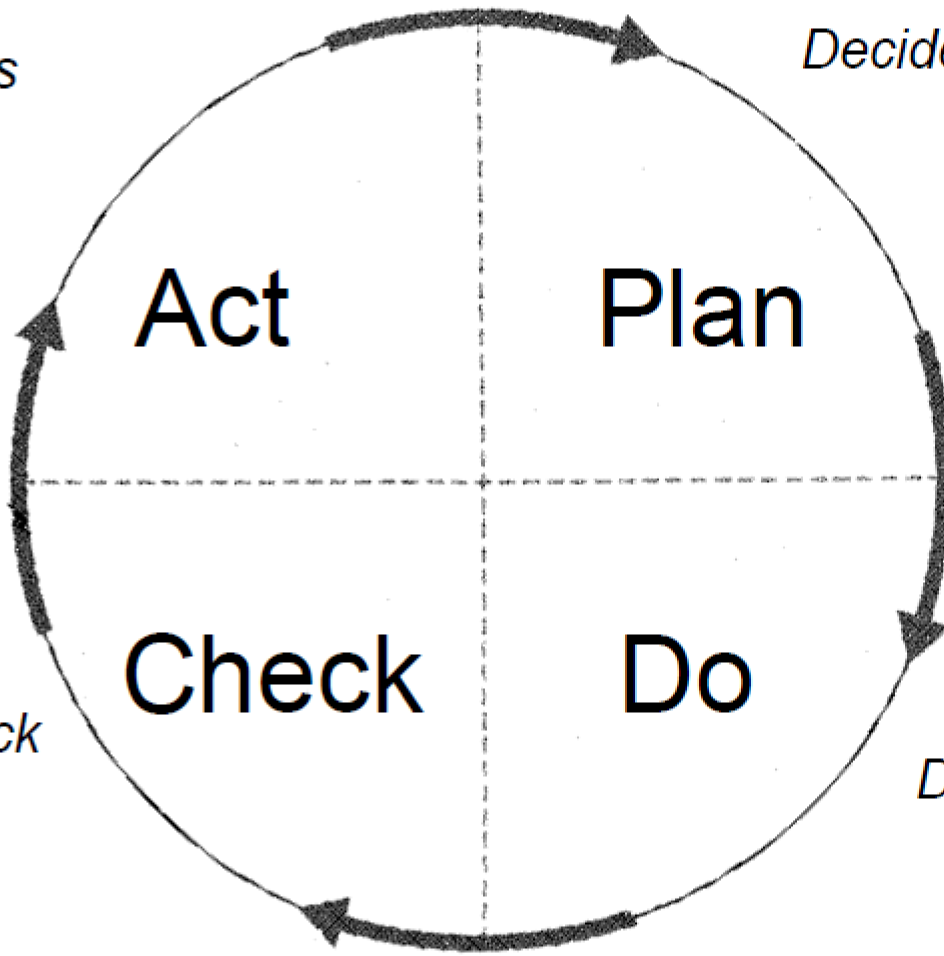
ANSI Z10 & CSA Z1000

Hold the gains

Decide what to do

Learn from experience

Identify how you will know if it worked



Measure it and check results against expectations

Do what you planned

Hazard Control Measures

Hierarchy of Hazard Control Measures
from ANSI Z10

Control Effectiveness

Life Cycle Value

Elimination
Eliminate the hazard during design

Substitution
Substitution of less hazardous equipment, system or energy

Engineering Controls
Design options that automatically reduces risk

Warnings
Automatic or manual, permanent or temporary, visible or audible warning systems, signs, barriers and labels

Administrative Controls
Planning processes, training, permits, safe work practices, maintenance systems, communications, and work management

Personal Protective Equipment
Available, effective, easy to use

Hazard Control Measures

outlined in ANSI Z10

Elimination | **Substitution** | **Engineering Controls** | **Warnings** | **Administrative Controls** | **PPE**

Addressed in
70E & Z462 Tables

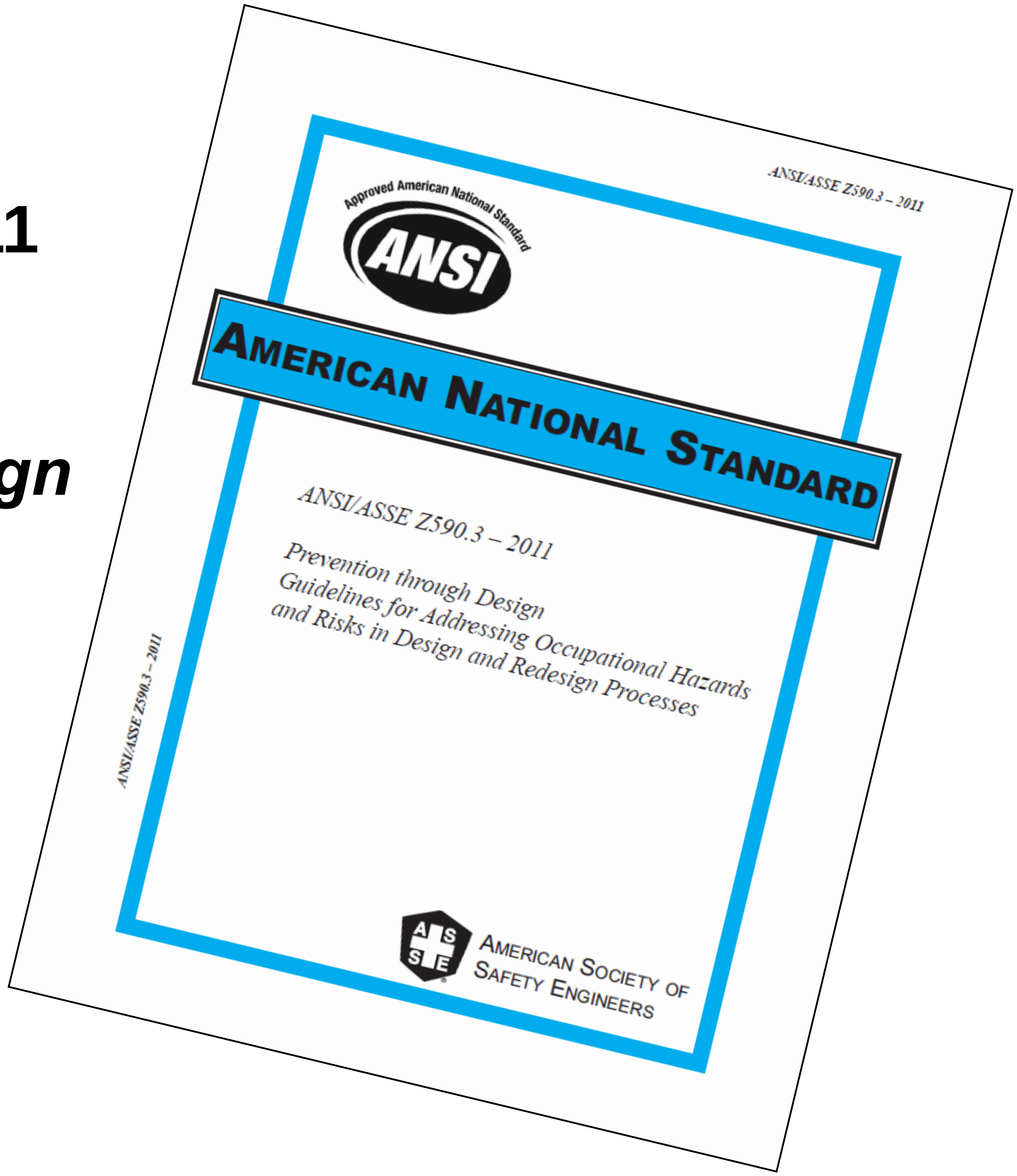
Addressed in 70E & Z462

Prevention ⟷ Protection

An effective electrical safety program incorporates <u>all</u> control measures

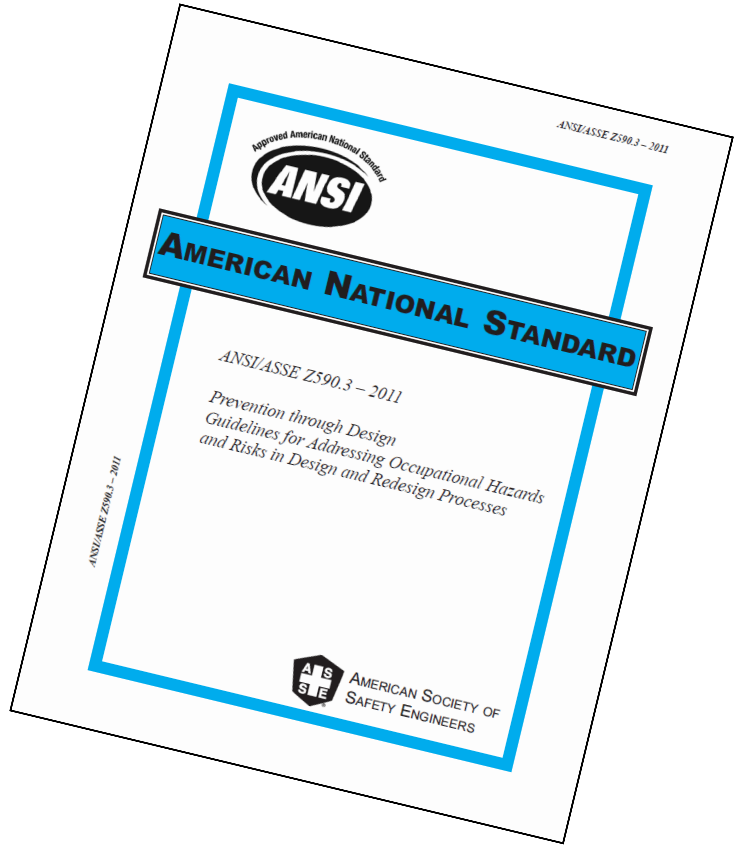
ANSI/ASSE Z590.3 – 2011
Prevention……

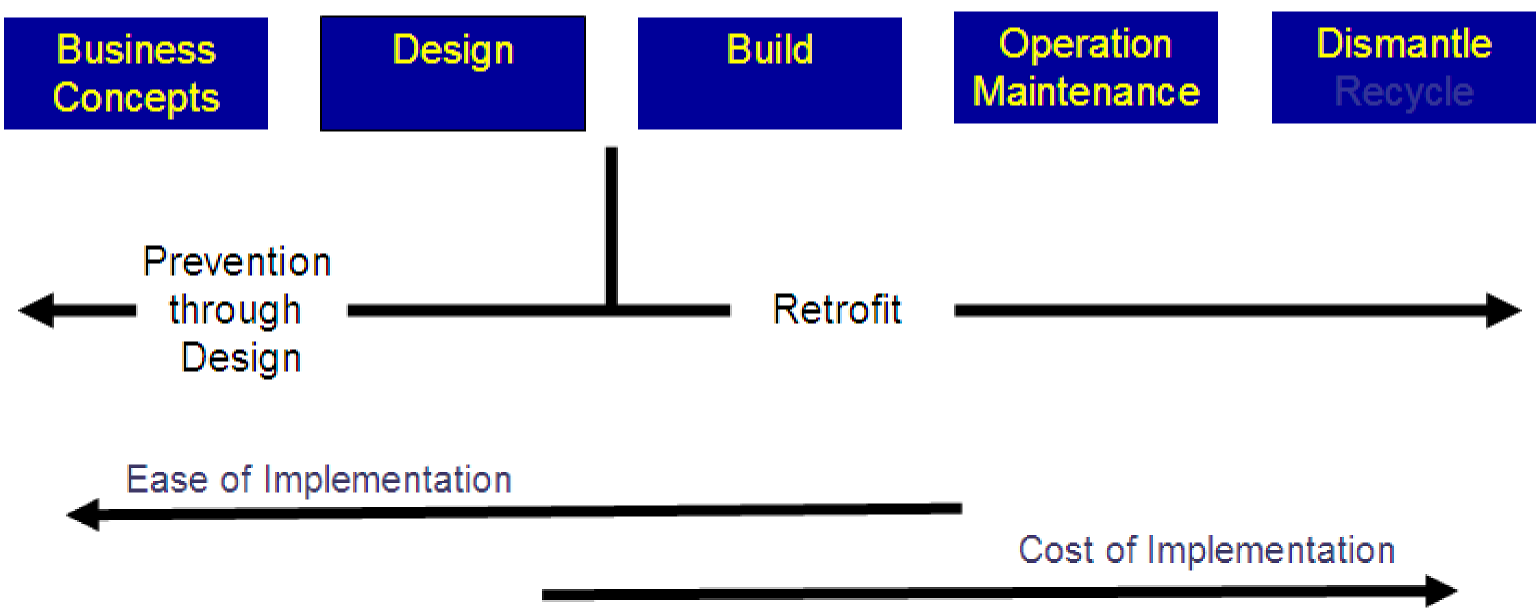
…..through Design

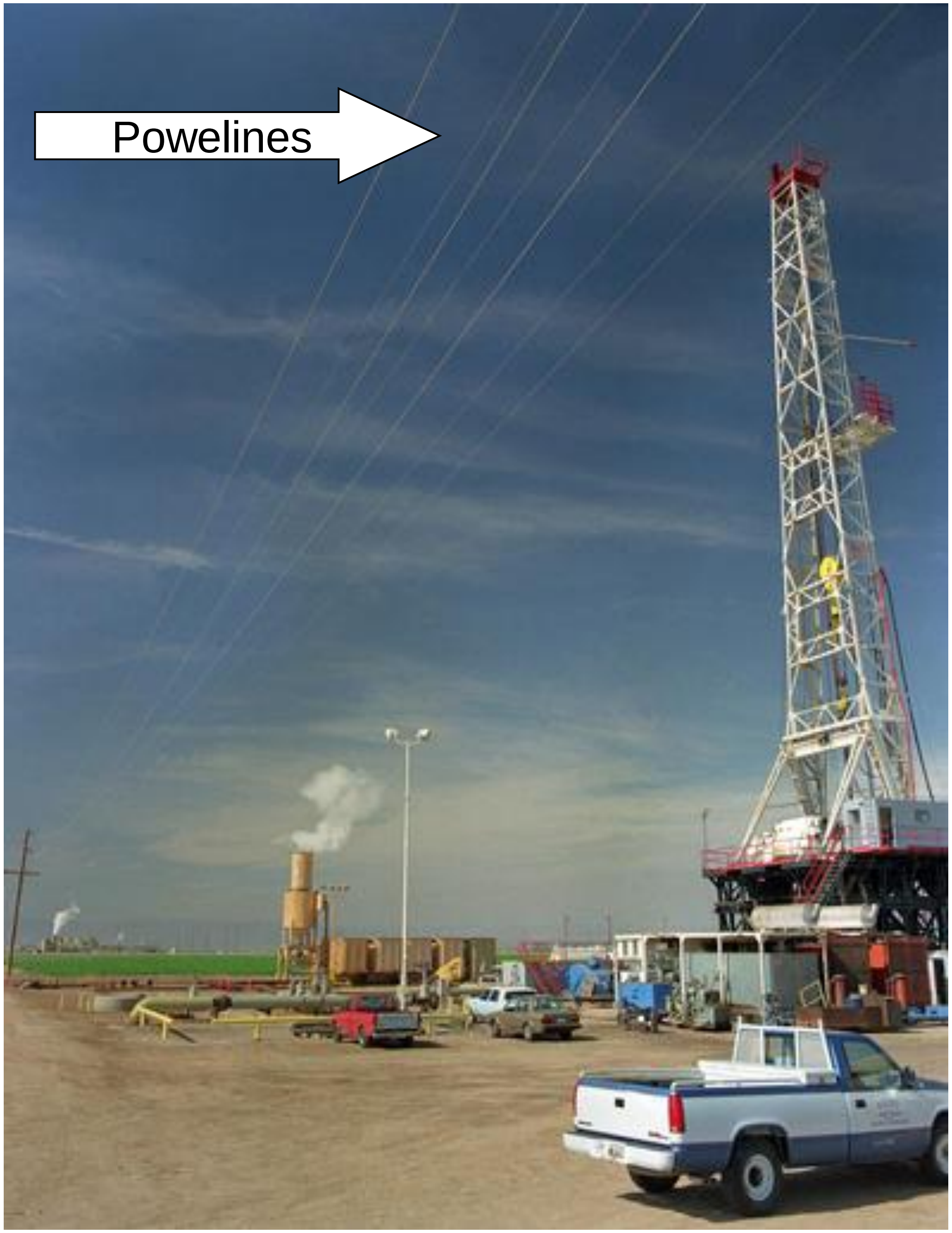


More than preventing injuries…

- Significant reductions will be achieved in injuries, illnesses and damage to property and the environment, and their attendant costs.
- Productivity will be improved.
- Operating costs will be reduced.
- Expensive retrofitting to correct design shortcomings will be avoided.

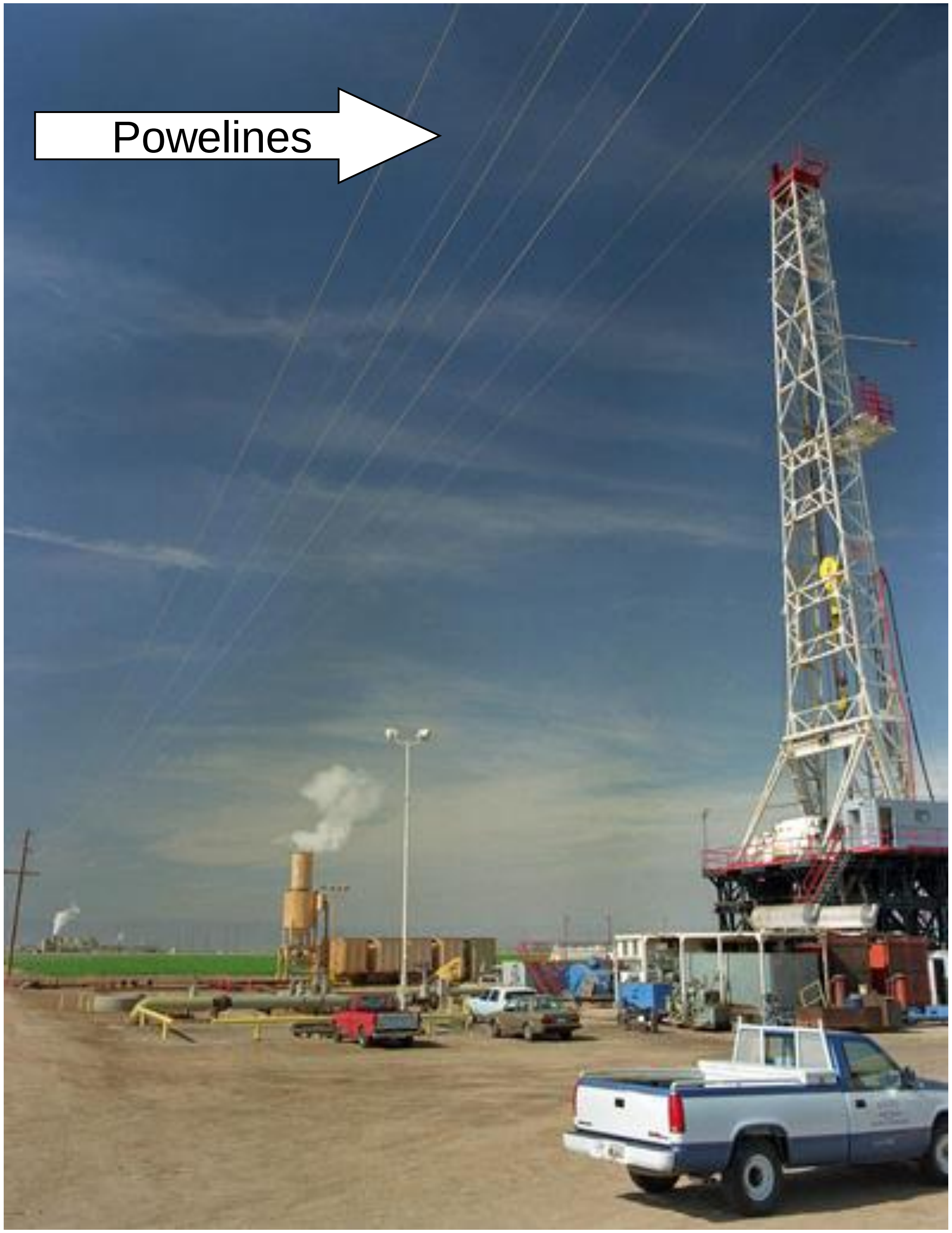






What is the best way to manage crane proximity to overhead power lines when servicing the drilling rig?

Permits, training, administrative procedures, PPE?



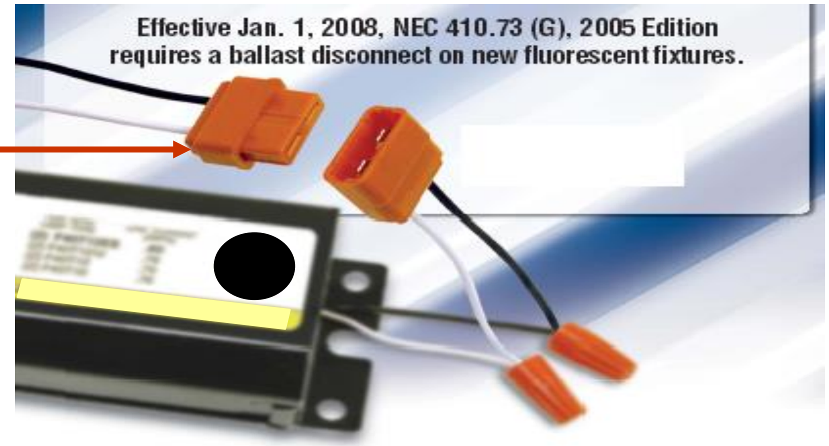
What is the best way to manage crane proximity to overhead power lines when servicing the drilling rig?

Or could the rig have been located further from the lines – eliminating the need for other, less effective hazard control measures?

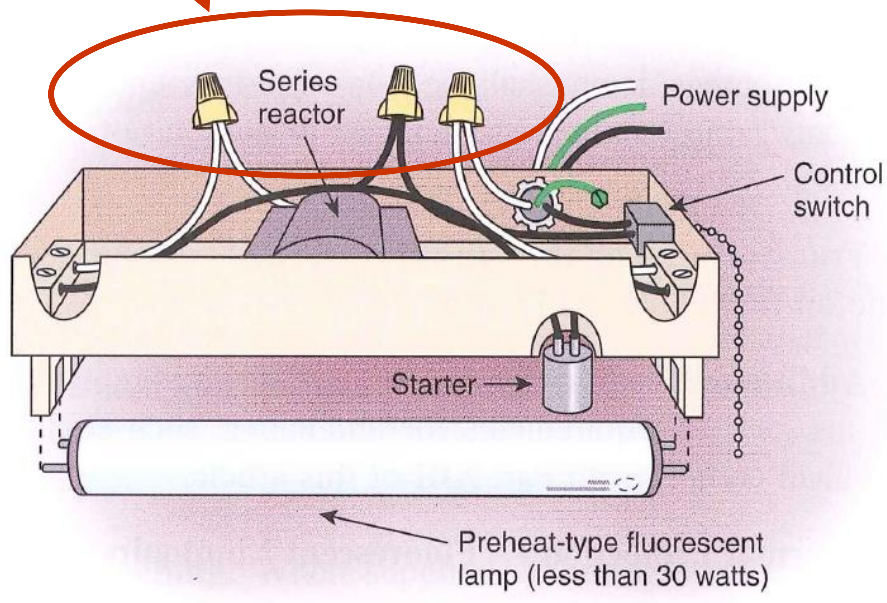
PtD
Prevention through Design

Impacting NFPA Standards

This is safer!



Touch safe disconnect device replaces traditional connections for lighting ballasts



Safety by Design

Example: Smart motor control centers

Smart MCC troubleshooting

Traditional troubleshooting

Safety by Design

Example: Testing & Troubleshooting Instruments

Functional, but….

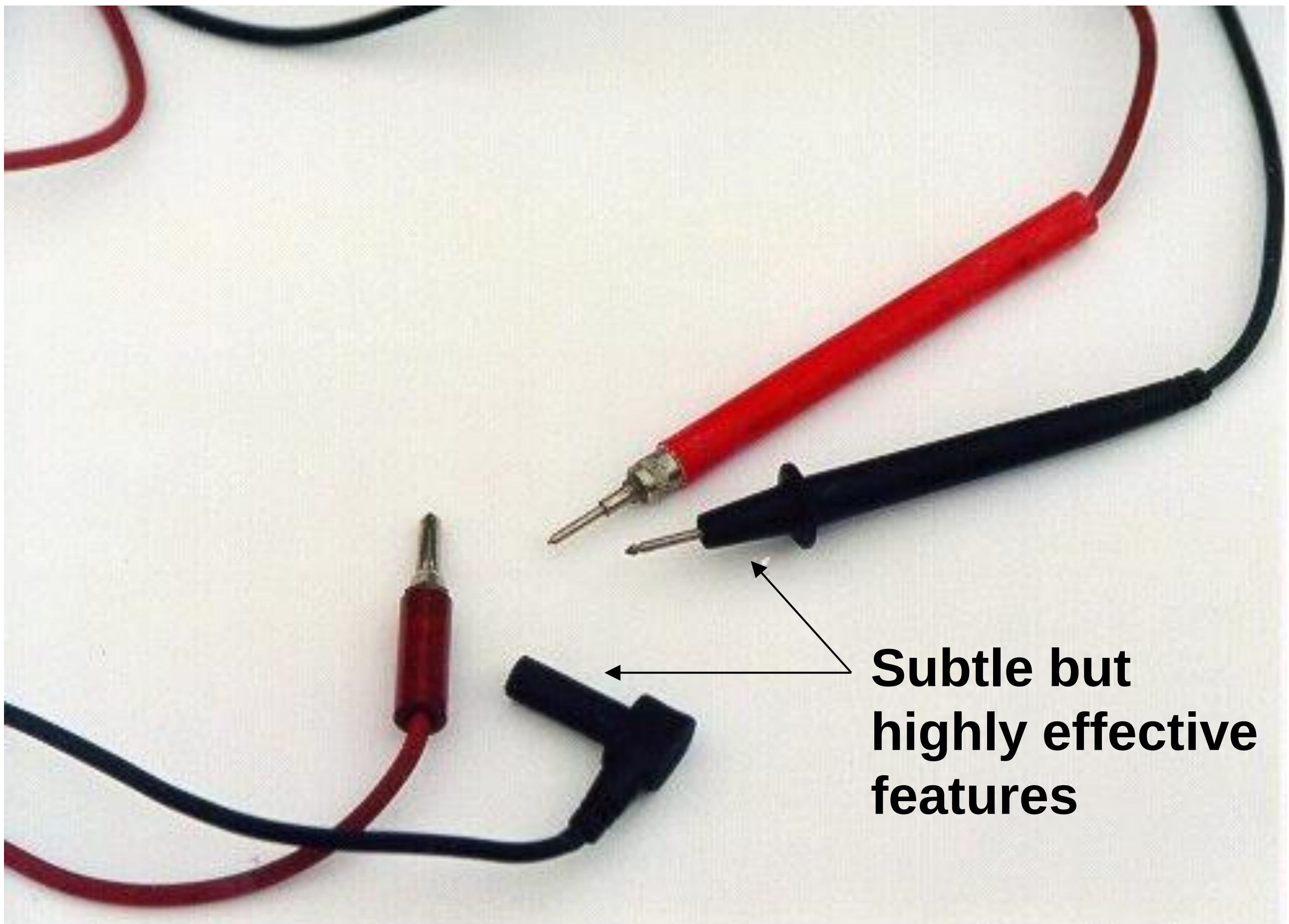
- **Highly dependent on error free operation**
- **Doesn't meet current product design standards**

19 positions on function selector
8 test lead connections
2 positions on ac/dc switch

Only one combination safe for testing 480V

Prevention through Design

Example: Testing & Troubleshooting Instruments



The red lead is functional, but….

- **Doesn't meet current product design standards**

Safety by Design

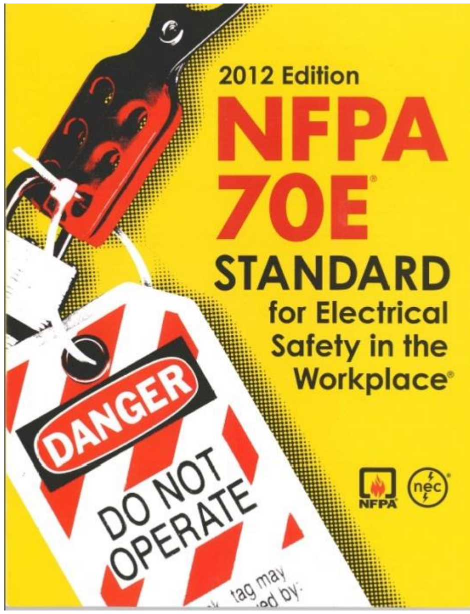
Example: Testing & Troubleshooting Instruments

An arc flash incident ready to happen. The energized, unguarded banana plug has slipped from the instrument and can contact the grounded enclosure.

Photo staged to illustrate the hazard

Substitution of less hazardous systems or equipment

Ports to allow thermographic & ultrasonic inspection without removing covers



Anticipated Changes for 2015

- Refinements in Chapter 1, Safe Work Practices
- Increased focus on Chapter 2 – Safety-Related Maintenance Requirements

Differentiating reliability for safety

- **Business operations continuity and uptime reliability needs may be cyclical**

- **Reliability needs for safety may be independent of continuity and uptime.**

Differentiating reliability for safety

- **Business operations continuity and uptime reliability needs may be cyclical**

- **Reliability needs for safety may be independent of continuity and uptime.**

Hazards don't care if you are in a recession

Some things have changed

Electrical safety intensity

Dependence on hardware reliability for arc flash mitigation

Maturity of safety & maintenance management systems

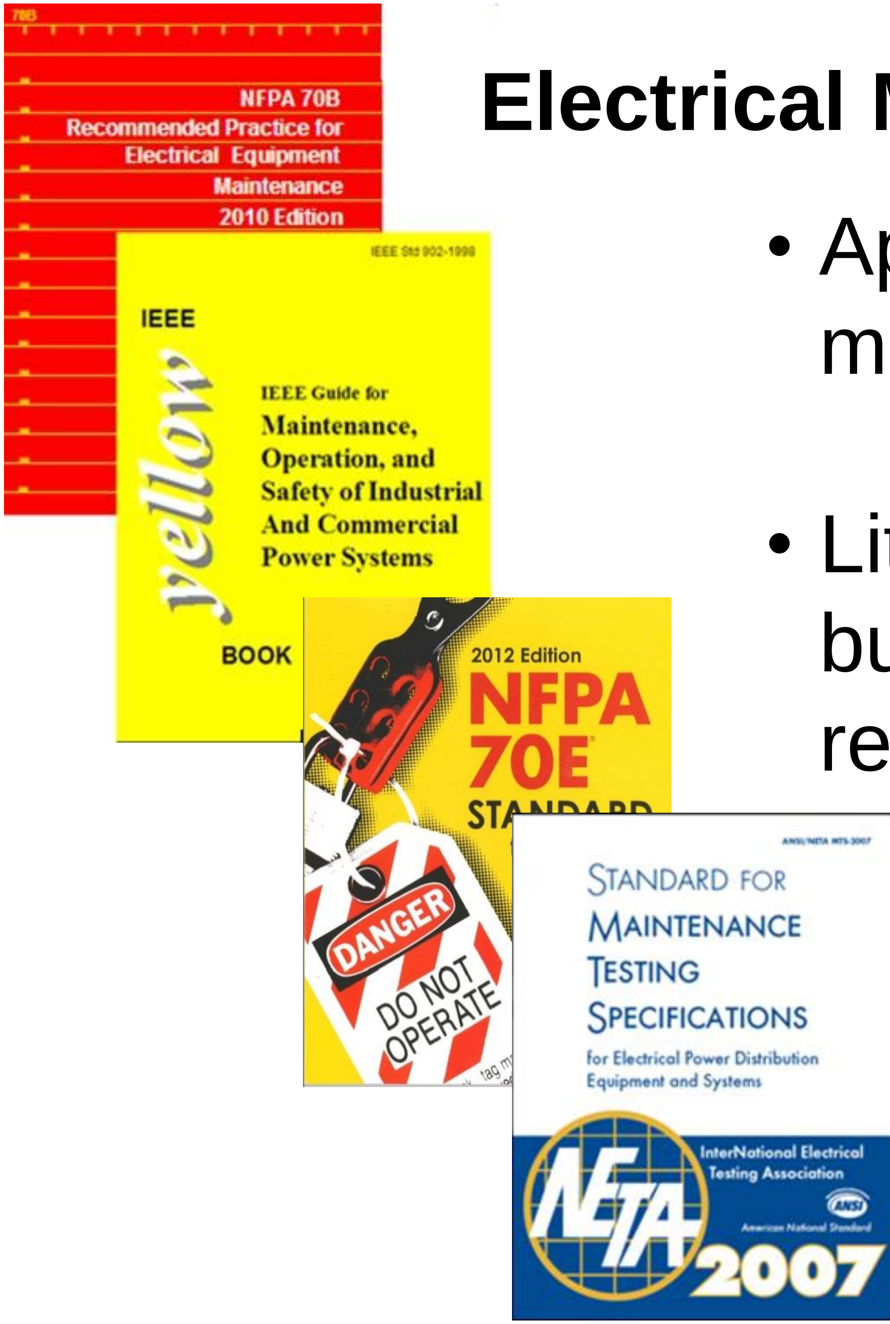
Can we be smarter…

… in establishing and prioritizing electrical equipment reliability?

… in applying inherently safer maintenance techniques?

… in integrating electrical safety and maintenance management systems?

Electrical Maintenance Standards



- Approach electrical maintenance in a general way
- Little differentiation regarding business objectives for reliability

Identifying equipment critical to electrical safety

Engineering controls depend on hardware, equipment and systems to prevent or reduce risk of injury

Examples:
- Circuit breakers
- Tripping power
- Fuses
- Enclosures
- Bonding & Grounding

Control Effectiveness

Hierarchy of Hazard Control Measures
from ANSI Z10

Elimination
Eliminate the hazard during design

Substitution
Substitution of less hazardous equipment, system or energy

Engineering Controls
Design options that automatically reduces risk

Warnings
Automatic or manual, permanent or temporary, visible or audible warning systems, signs, barriers and labels

Administrative Controls
Planning processes, training, permits, safe work practices, maintenance systems, communications, and work management

Personal Protective Equipment
Available, effective, easy to use

Life Cycle Value

Examples of engineering controls critical to electrical safety

- Short circuit protection systems
  - Limit arc flash energy
  - Includes fuses, circuit breakers, protective relay systems, batteries for tripping power

Examples of engineering controls critical to electrical safety

- Doors, covers, fences
  - Primary means to prevent unintentional contact with lethal energy

Enclosure integrity is a first line of protection to prevent exposure to electrical hazards

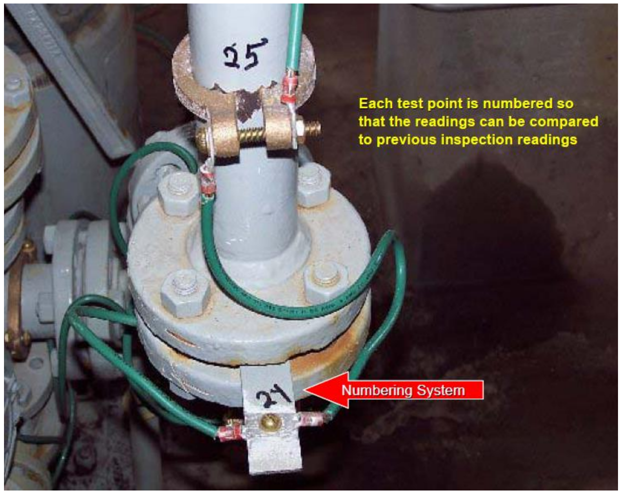
Examples of engineering controls critical to electrical safety

- GFCIs, grounding and bonding
  - Guard against lethal electric shock exposure

21

Safety-Related Maintenance

Bonding and grounding integrity is critical to shock protection and operation of fault protective devices



A factor in arcing damage…

…to equipment

…to people

Essential for Protection from Electric Shock

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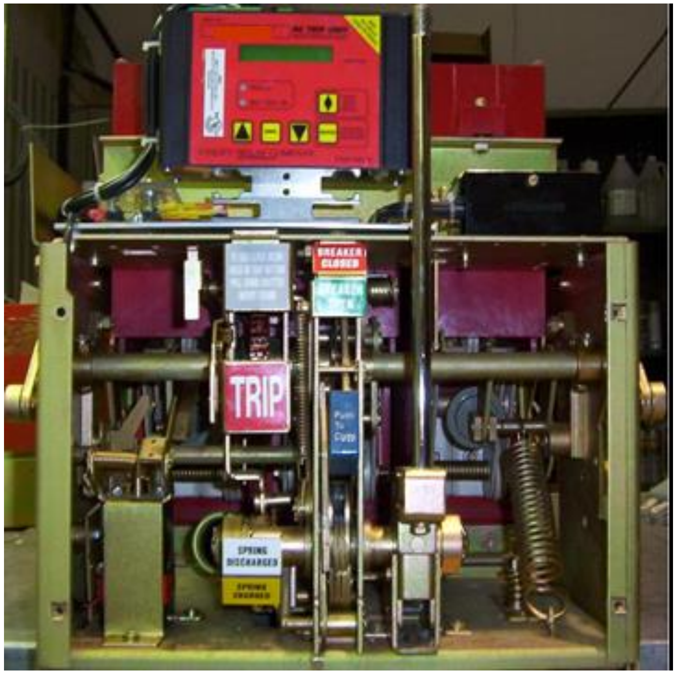
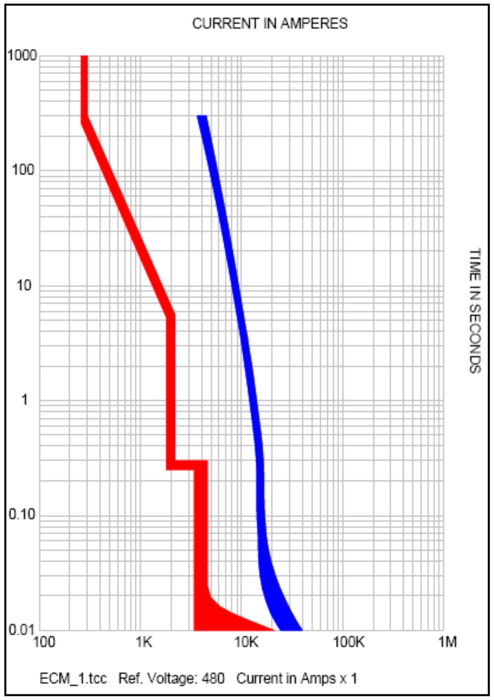
Safety-Related Maintenance

Circuit breakers **must** function as designed

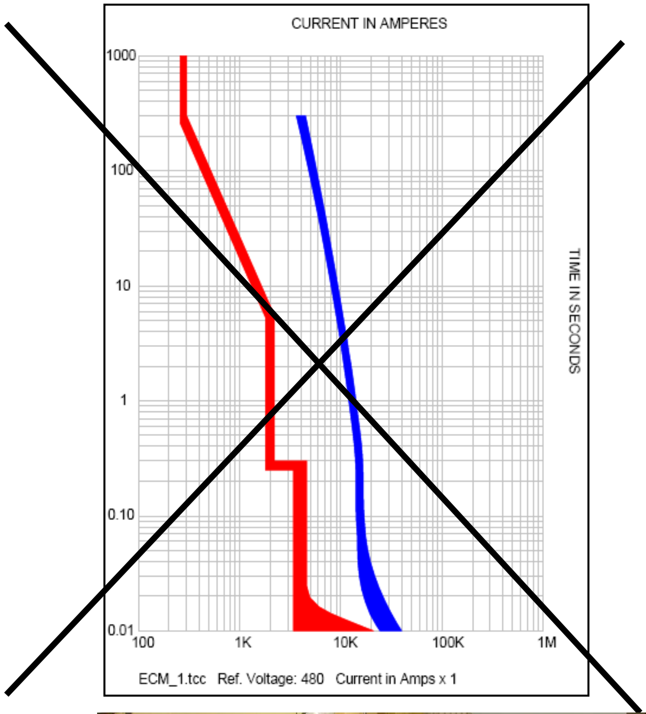
- The circuit breaker
- The protective relaying and auxiliaries
- The tripping power (batteries or other system)
- The trip settings must be those documented in the design and in the arc flash study

Otherwise the thermal energy transfer in an arc flash event can be orders of magnitude greater than that expected.

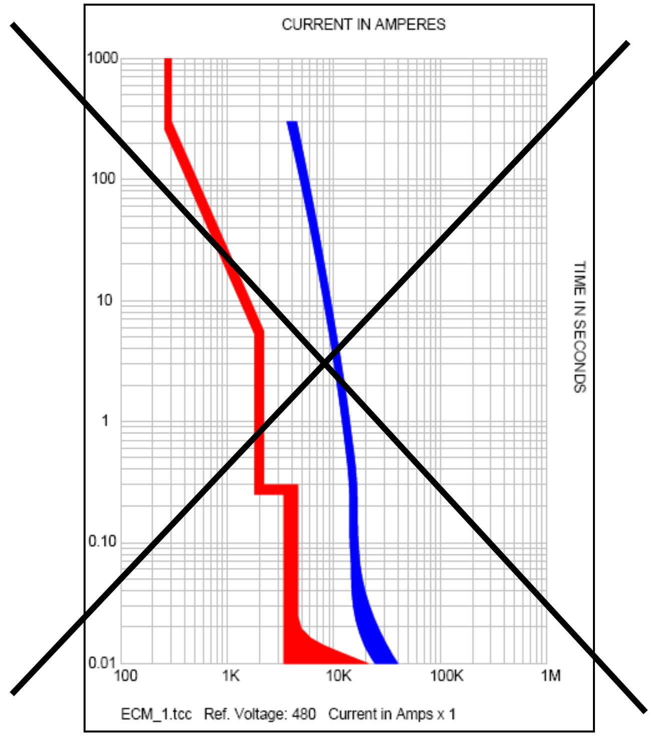




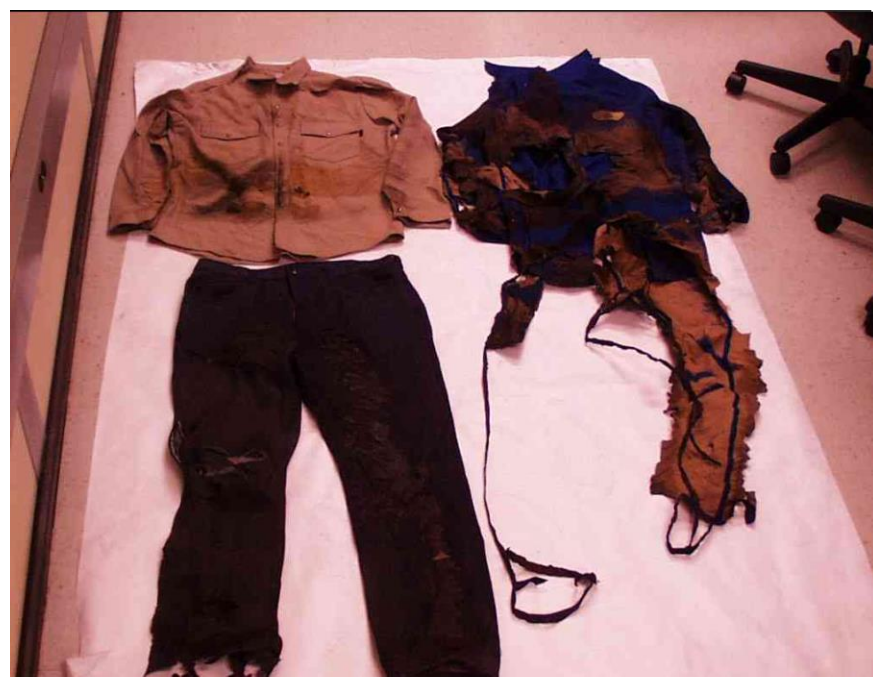
The workers have selected PPE based on the arc flash incident energy analysis



If the breaker trip time is longer than that used to calculate the incident energy…..



The thermal energy transfer in an arc flash event can be much greater than the PPE Arc Rating.



83

Safety-Related Maintenance

The installed fuse **<u>must</u>** be the fuse documented in the design and arc flash study

- Class
- Ampere rating
- Interrupting rating

Otherwise the thermal energy transfer in an arc flash event can be orders of magnitude greater than that expected.

Safety-Related Maintenance

Enclosure integrity is a first line of protection to prevent exposure to electrical hazards

Inherently safer maintenance technologies

- **Smart Substations and Motor Control Centers**
  - Utilize "smart" equipment to gather equipment operating data
  - Automated data monitoring and alarm on deviations
    - Low load for operating motor (pump problem?)
    - Overload condition (time to trip?)
    - High number of operations (schedule maintenance?)

Inherently safer maintenance technologies

Substitution of less hazardous systems or equipment

Ports to allow thermographic & ultrasonic inspection without removing covers

Create an extraordinary collaboration

Technical experts: Reliability Engineers, Electricians, Electrical Engineers

- Skill in maintenance management systems
- Skill in design, construction, maintenance, operation of electrical equipment and systems

Safety Professionals

- Skill in safety management systems and risk management

Management

- Responsible for managing priorities, resources, and business objectives

Opportunities

1. Does your maintenance program and practices identify and prioritize equipment critical to electrical safety?
2. Do you design new facilities to incorporate application of inherently safer maintenance technologies?
3. How well have you integrated electric power equipment into your business decisions addressing maintenance management systems?
4. How well have you integrated the electrical safety program into your maintenance management systems?
5. Can equipment and systems be smarter so we know when an engineering control has failed?
6. Do we have the right mix of expertise in our standards related to electrical maintenance?

Summary

1. It is not just one standard
2. Safety management systems standards provide a framework for a holistic, sustainable electrical safety program
3. Standards are often historical documentation of 25 year old innovations. You may need to look beyond standards for state of the art ideas.

A 20 Year Case History

Demonstrating Results

In the mid 1980s

- **Anecdotal trends in increasing injuries from electrical hazards**
- **Beginnings of large scale MOC-Personnel**
- **Recognition that arc flash was a unique hazard**
- **Awareness that electrical hazards were significant when looking at fatalities, but virtually invisible when looking at Total Recordable Injuries**
- **Corporate Electrical Safety Team established in 1989**

Wilmington News Journal Monday June 7, 1982

Engineer, safety expert, William White dies at 66

William J. White Jr.

William J. White Jr., 66 of Newark, a DuPont employee for 48 years, died Saturday in Front Royal, VA.

Mr. White, an electrical engineer and safety expert at the DuPont corporate engineering center was temporarily working last week at the firm's plant near Front Royal.

He had been helping to prepare the plant for its annual high voltage inspection when, while standing near an electrical substation about 8 in the morning, he collapsed.

He was rushed to the hospital in a coma. Company officials are investigating the possibility he suffered an electric shock.

Mr. White was born in Pulaski, TN. He started in construction with DuPont in 1934 and worked at a number of plant and construction sites before his transfer to the engineering department in 1954 as an engineering specialist and to the engineering services division in 1962, while advancing to the position of senior consultant.

He was a member of the Delaware Association of Professional Engineers, the National Fire Protection Association, the Chemical Manufacturers Association and the Institute of Electrical and Electronics Engineers.

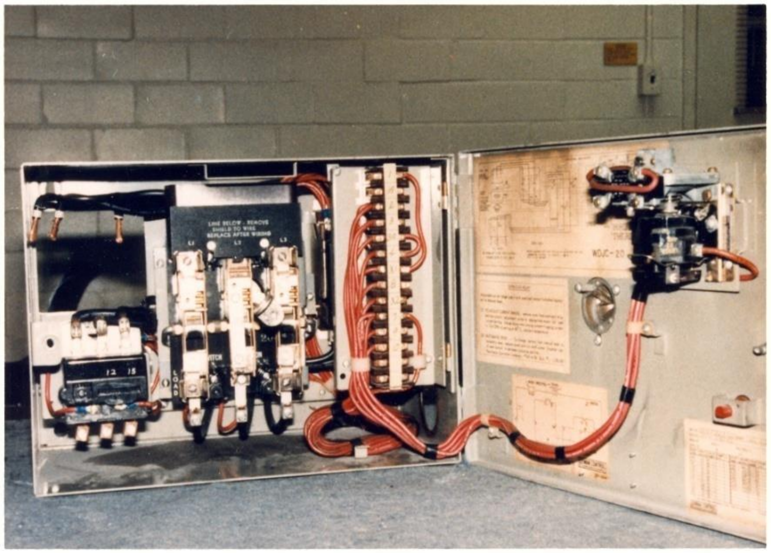
Mr. White is survived by his wife Doris, sons Robert and Charles, mother Jessie, brother Charles, and two grandchildren.

Services will be Wednesday morning at 11 at the Warwick Funeral Home in Newark, where friends may call tonight from 7 to 9. Burial will be in All Saints Cemetery.

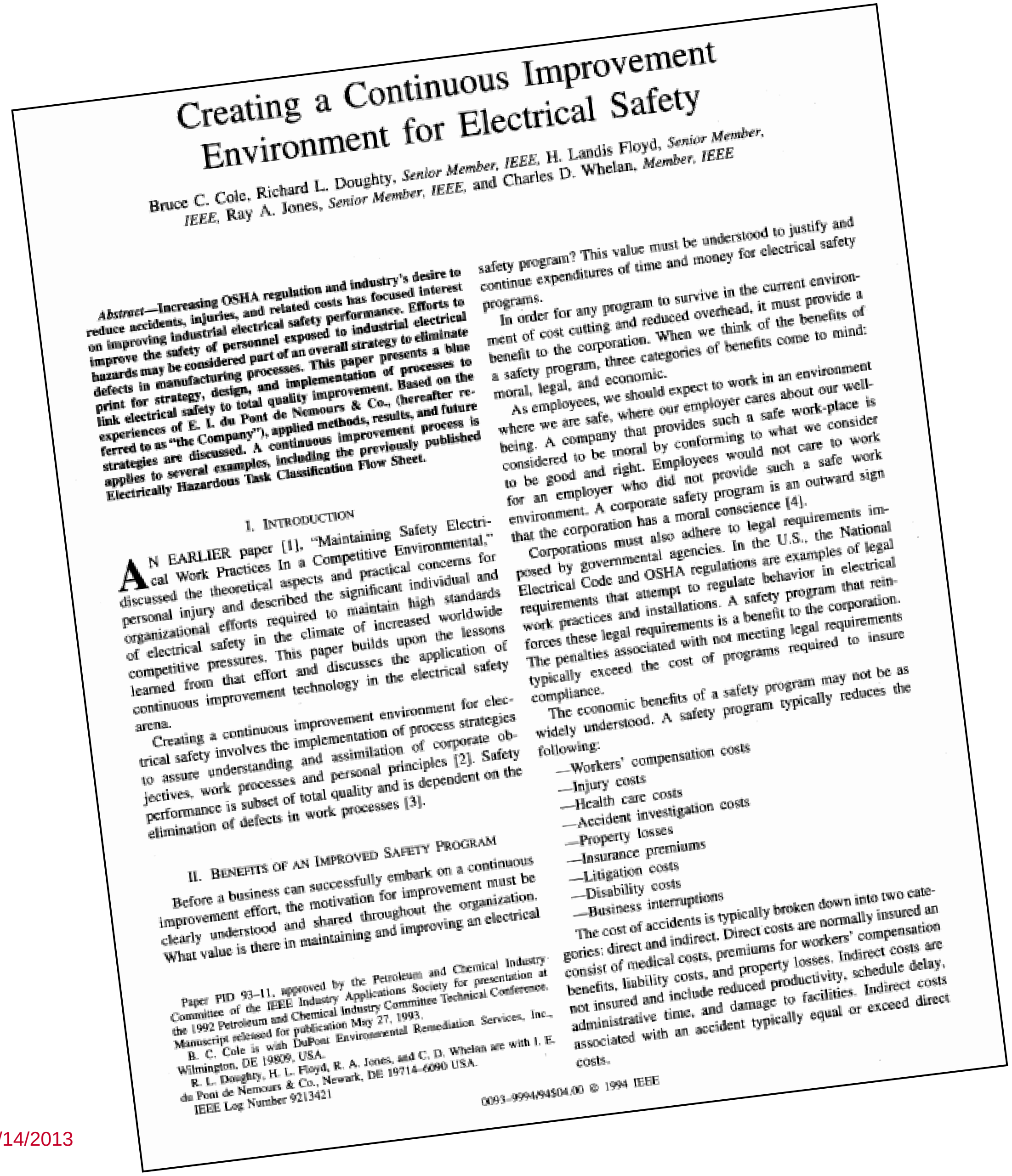
Between 1980 and 1990, five employees and contractors suffered fatal injuries from contact with electrical energy in DuPont operations. This was one of these fatalities.

In 1989, DuPont made a highly visible commitment to reduce the risk of injuries to employees and contractors from electrical hazards. Goals for sustainable improvement were established, financial support provided and dedicated people empowered to change the electrical safety culture and reduce the likelihood of electrical incidents, injuries and fatalities.

An arc flash injury - 1983



1992



Creating a Continuous Improvement Environment for Electrical Safety

Bruce C. Cole, Richard L. Doughty, *Senior Member, IEEE*, H. Landis Floyd, *Senior Member, IEEE*, Ray A. Jones, *Senior Member, IEEE*, and Charles D. Whelan, *Member, IEEE*

Abstract—Increasing OSHA regulation and industry's desire to reduce accidents, injuries, and related costs has focused interest on improving industrial electrical safety performance. Efforts to improve the safety of personnel exposed to industrial electrical hazards may be considered part of an overall strategy to eliminate defects in manufacturing processes. This paper presents a blue print for strategy, design, and implementation of processes to link electrical safety to total quality improvement. Based on the experiences of E. I. du Pont de Nemours & Co., (hereafter referred to as "the Company"), applied methods, results, and future strategies are discussed. A continuous improvement process is applies to several examples, including the previously published Electrically Hazardous Task Classification Flow Sheet.

I. Introduction

An EARLIER paper [1], "Maintaining Safety Electrical Work Practices In a Competitive Environmental," discussed the theoretical aspects and practical concerns for personal injury and described the significant individual and organizational efforts required to maintain high standards of electrical safety in the climate of increased worldwide competitive pressures. This paper builds upon the lessons learned from that effort and discusses the application of continuous improvement technology in the electrical safety arena.

Creating a continuous improvement environment for electrical safety involves the implementation of process strategies to assure understanding and assimilation of corporate objectives, work processes and personal principles [2]. Safety performance is subset of total quality and is dependent on the elimination of defects in work processes [3].

II. Benefits of an Improved Safety Program

Before a business can successfully embark on a continuous improvement effort, the motivation for improvement must be clearly understood and shared throughout the organization. What value is there in maintaining and improving an electrical safety program? This value must be understood to justify and continue expenditures of time and money for electrical safety programs.

In order for any program to survive in the current environment of cost cutting and reduced overhead, it must provide a benefit to the corporation. When we think of the benefits of a safety program, three categories of benefits come to mind: moral, legal, and economic.

As employees, we should expect to work in an environment where we are safe, where our employer cares about our well-being. A company that provides such a safe work-place is considered to be moral by conforming to what we consider to be good and right. Employees would not care to work for an employer who did not provide such a safe work environment. A corporate safety program is an outward sign that the corporation has a moral conscience [4].

Corporations must also adhere to legal requirements imposed by governmental agencies. In the U.S., the National Electrical Code and OSHA regulations are examples of legal requirements that attempt to regulate behavior in electrical work practices and installations. A safety program that reinforces these legal requirements is a benefit to the corporation. The penalties associated with not meeting legal requirements typically exceed the cost of programs required to insure compliance.

The economic benefits of a safety program may not be as widely understood. A safety program typically reduces the following:

—Workers' compensation costs
—Injury costs
—Health care costs
—Accident investigation costs
—Property losses
—Insurance premiums
—Litigation costs
—Disability costs
—Business interruptions

The cost of accidents is typically broken down into two categories: direct and indirect. Direct costs are normally insured and consist of medical costs, premiums for workers' compensation benefits, liability costs, and property losses. Indirect costs are not insured and include reduced productivity, schedule delay, administrative time, and damage to facilities. Indirect costs associated with an accident typically equal or exceed direct costs.

Paper PID 93–11, approved by the Petroleum and Chemical Industry Committee of the IEEE Industry Applications Society for presentation at the 1992 Petroleum and Chemical Industry Committee Technical Conference. Manuscript released for publication May 27, 1993.
B. C. Cole is with DuPont Environmental Remediation Services, Inc., Wilmington, DE 19809, USA.
R. L. Doughty, H. L. Floyd, R. A. Jones, and C. D. Whelan are with I. E. du Pont de Nemours & Co., Newark, DE 19714-6090 USA.
IEEE Log Number 9213421

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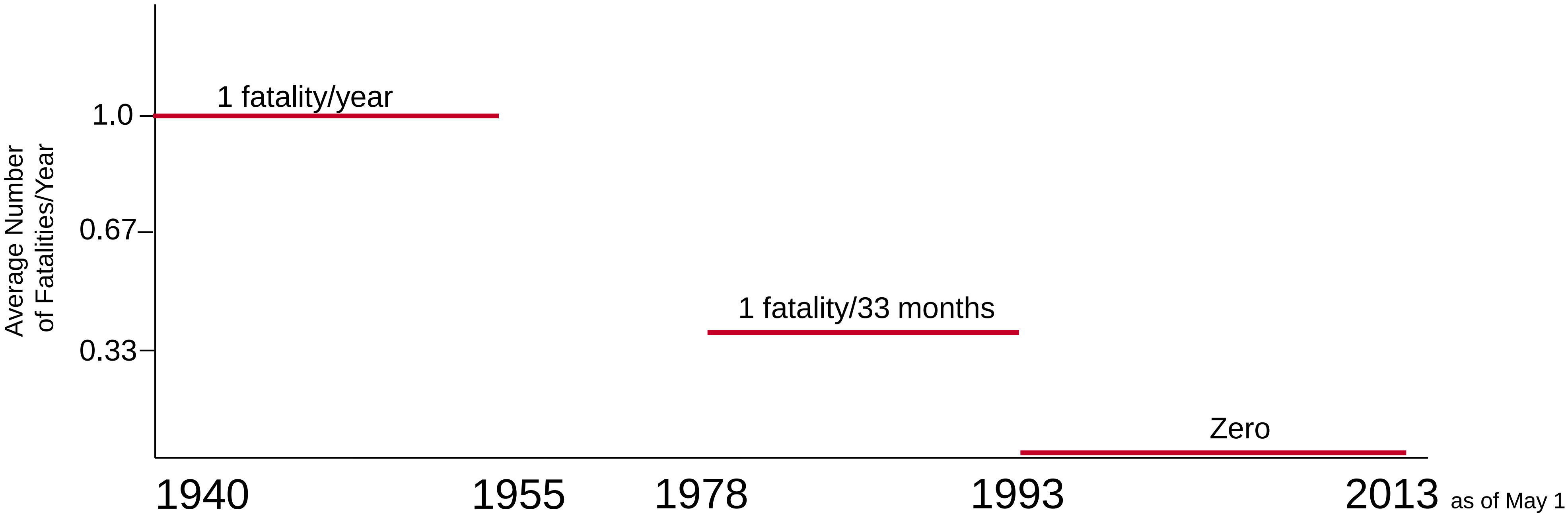
1. Understand the business consequences of electrical incidents
2. Engage all employees
3. Stimulate near miss reporting
4. Apply quality improvement model
5. Build networks
6. Challenge accepted practices
7. Improve collaboration among management, electrical experts and safety professionals
8. Use standards as tools
9. Promote prevention by design
10. Address life cycle: design, construct, operate, maintain, dismantle

Trends in Electrocution Fatalities in DuPont Operations

Employees and Contractors



Notes

1. No data available for 1955-78
2. 1953 marked beginning of a culture shift to eliminate accepted practice of working on energized circuits
3. Corporate Electrical Safety Team established in 1989 to further shift electrical safety culture in DuPont
   - Focus on near miss incident learnings, line management engagement, improved auditing processes, fundamentals i.e. "Test Before Touch"; Engineering Std E1Z established as default electrical safety performance standard and evolved to SHE Standard S31G in 2003
4. Electrocution in 2001 occurred in Pioneer; within 24 months of acquisition, non-operations, customer service support in customer facility
5. Electrocution remains 5th leading cause of occupational fatality in the US

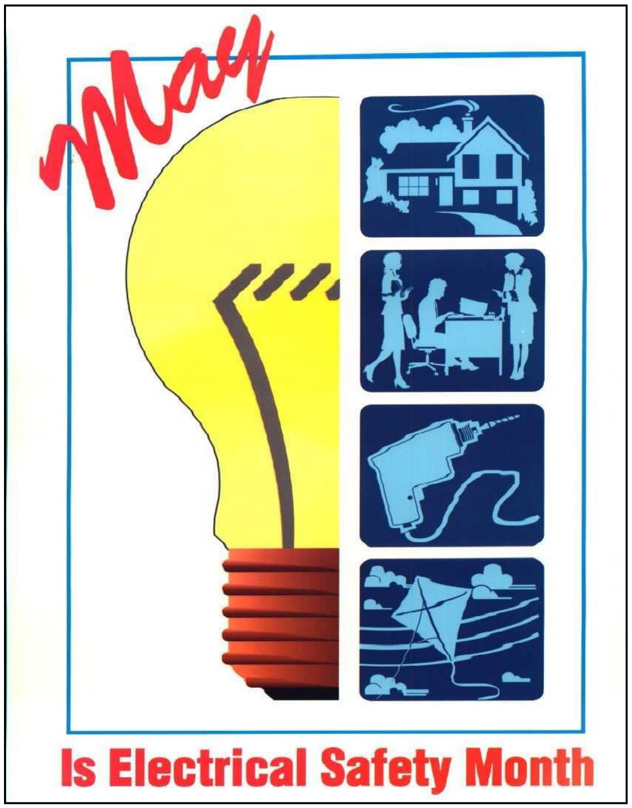
Consequences of an incident in electrical systems critical to your business

- Energy utilization
- On time delivery
- Environmental releases
- Raw material utilization
- First pass yield
- Operations uptime
- Worker safety

Potential Consequences

- Personal injury
- Disruption to operations
- Damage to critical equipment
- Process safety implications
- Waste of raw materials and energy
- Unhappy customers

Engage all employees



1989 - DuPont

ESFi
Electrical Safety Foundation International

1994 – Sponsors
National Electrical Safety Month

Stimulating Near-Miss Reporting

Promoted awareness on what constitutes a near miss with electrical hazards:

"an event resulting from personnel action or equipment failure involving electrical installation, portable electrical equipment or electrical test equipment that has the potential to result in am injury due to: 1) electrical flash or burn, 2) electrical shock from a source greater than 50 volt AC or 100 volt DC, or 3) reflex action to an electrical shock (any voltage)."

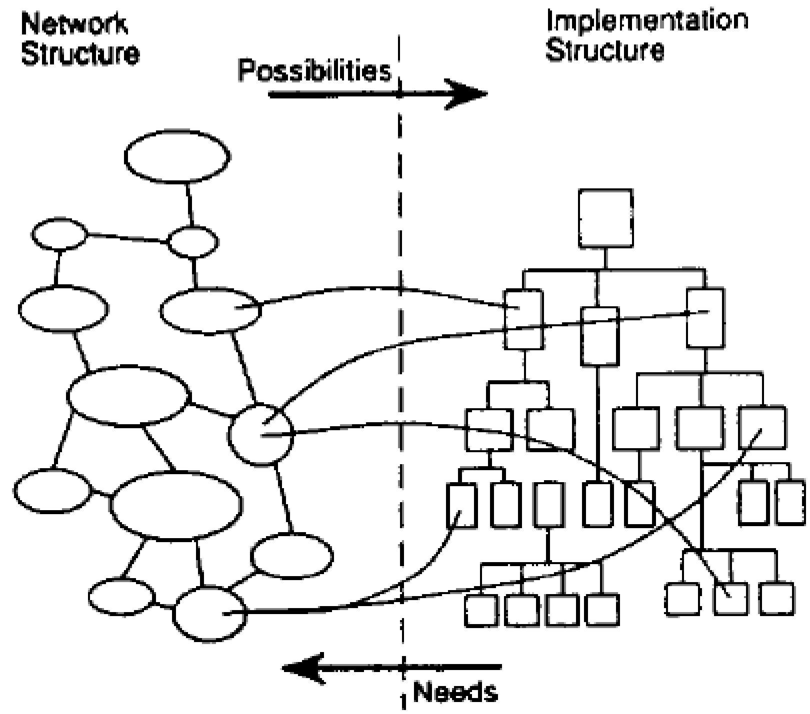
Result: 100 X increase in incident reporting

Electrical Safety Networks

Internal

- Site
- Business
- Regional
- Corporate

External….



IEEE Electrical Safety Workshop

…an international forum for changing the electrical safety culture and serving to advance application of technology, work practices, codes and regulations to prevent electrical incidents and injuries in the workplace…

- Fundamental & Advanced Tutorials
- Products & Services Exposition
- Standards Working Groups
- Expert Presentations
- Technical Tours
- Extraordinary networking

changing the electrical safety culture

- **Established 1992, with 35 participants**
- **Today: 400+ participants, 300+ organizations**

ESW 2014

San Diego, California • February 4 – 7, 2014

Challenge Accepted Practices

The following article was in the American Electricians' Handbook editions 1 – 7 from 1913 to 1961

AMERICAN ELECTRICIANS' HANDBOOK
7th Edition 1953 McGraw-Hill

154. Electricians often test circuits for the presence of voltage by touching the conductors with the fingers. This method is safe where the voltage does not exceed 250 and is often very convenient for locating a blown-out fuse or for ascertaining whether or not a circuit is alive. Some men can endure the electric shock that results without discomfort whereas others cannot. Therefore, the method is not feasible in some cases.

AMERICAN ELECTRICIANS' HANDBOOK
7th Edition 1953 McGraw-Hill

154, *continued.* Which are the outside wires and which is the neutral wire of a 115/230-volt, three-wire system can be determined in this way by noting the intensity of the shock that results by touching different pairs of wires with fingers. Use the method with caution and be certain that the voltage of the circuit does not exceed 250 before touching the conductors. (This and several paragraphs that follow are taken from *Electrical Engineering*.)

AMERICAN ELECTRICIANS' HANDBOOK
7th Edition 1953 McGraw-Hill

155. The presence of low voltages can be determined by tasting. The method is feasible only where the pressure is but a few volts and hence is used only in bell and signal work. Where the voltage is very low, the bared ends of the conductors constituting the two sides of the circuit are held a short distance apart on the tongue. If voltage is present a peculiar mildly burning sensation results, which will never be forgotten after one has experienced it. The taste is due to the electrolytic decomposition of the liquids on the tongue which produces a salt having a taste.

AMERICAN ELECTRICIANS' HANDBOOK
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155, *continued.* With voltages of 4 or 5 volts, due to as many cells of a battery, it is best to test for the presence of voltage by holding one of the bared conductors in the hand and touching the other to the tongue. Where a terminal of the battery is grounded, often a taste can be detected by standing on moist ground and touching a conductor from the other battery terminal to the tongue. Care should be exercised to prevent the two conductor ends from touching each other at the tongue, for if they do a spark can result that may burn.

A different paradigm…

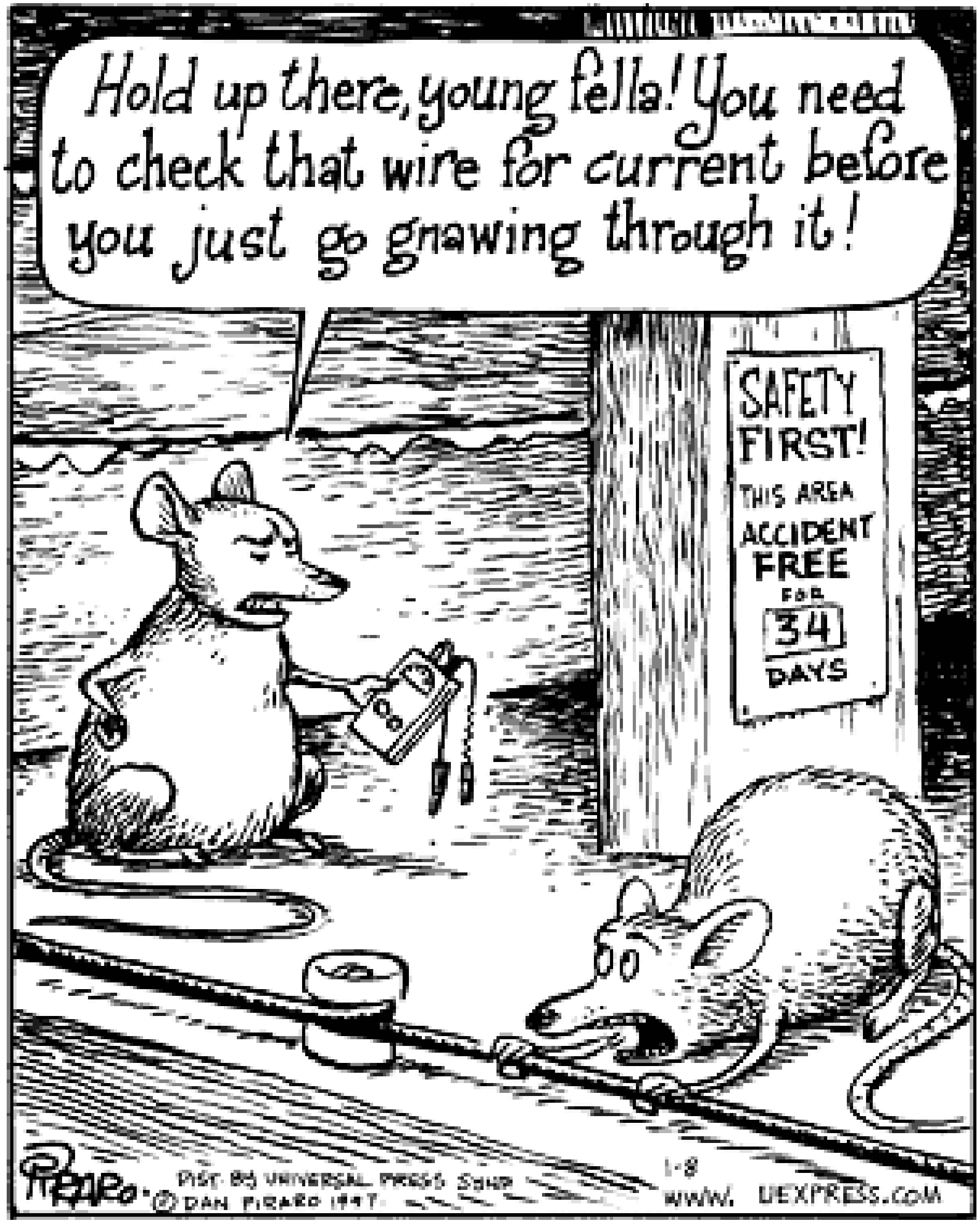
Test
Every Circuit, Every Conductor, Every Time *Before* You *Touch!*

It Could Save Your Life!

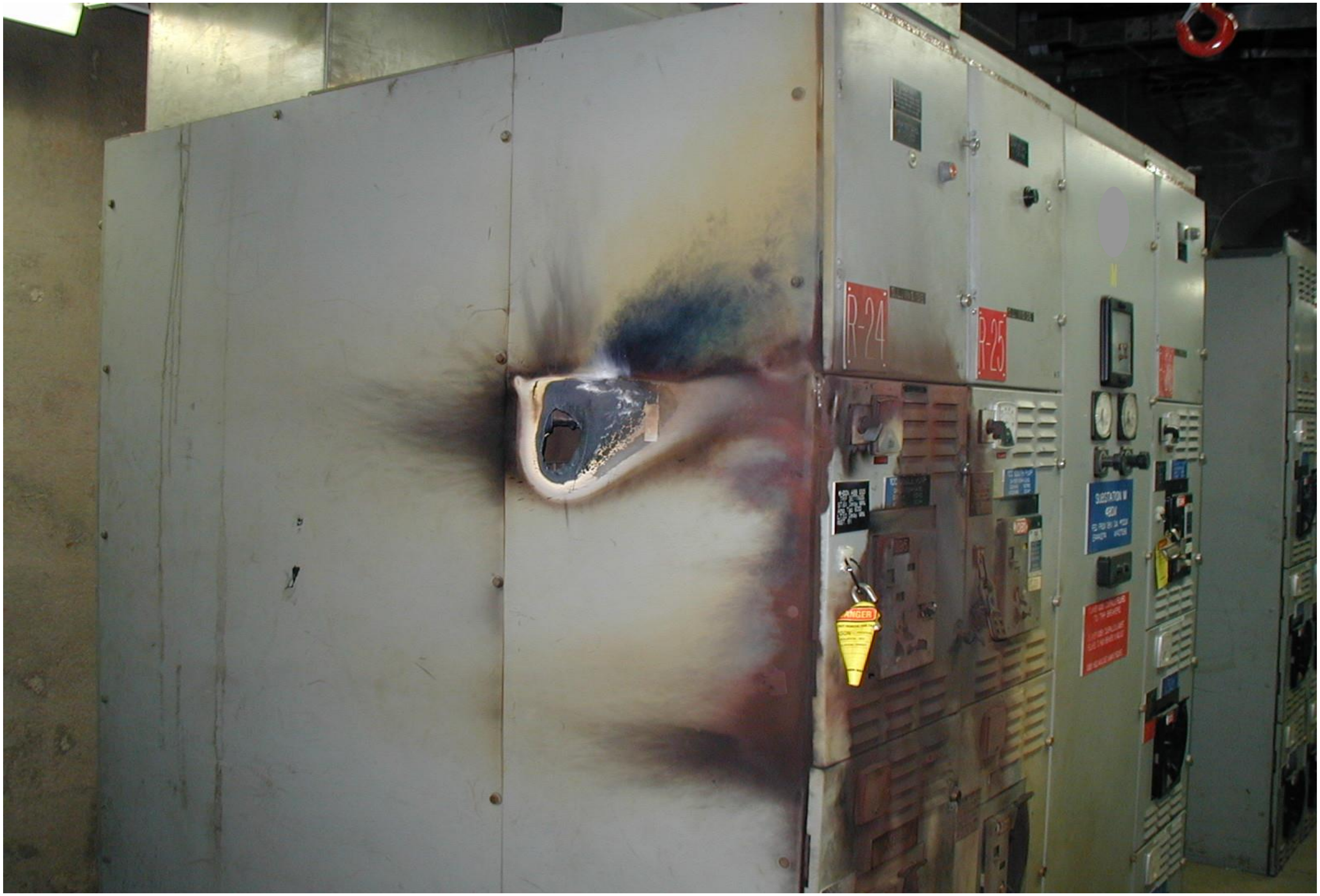

TEST
BEFORE TOUCH

Bizarro
by Dan Piraro

published January 8, 1997
by Universal Press
Syndicate



Can I reduce PPE if the door is closed?



Safety by Design

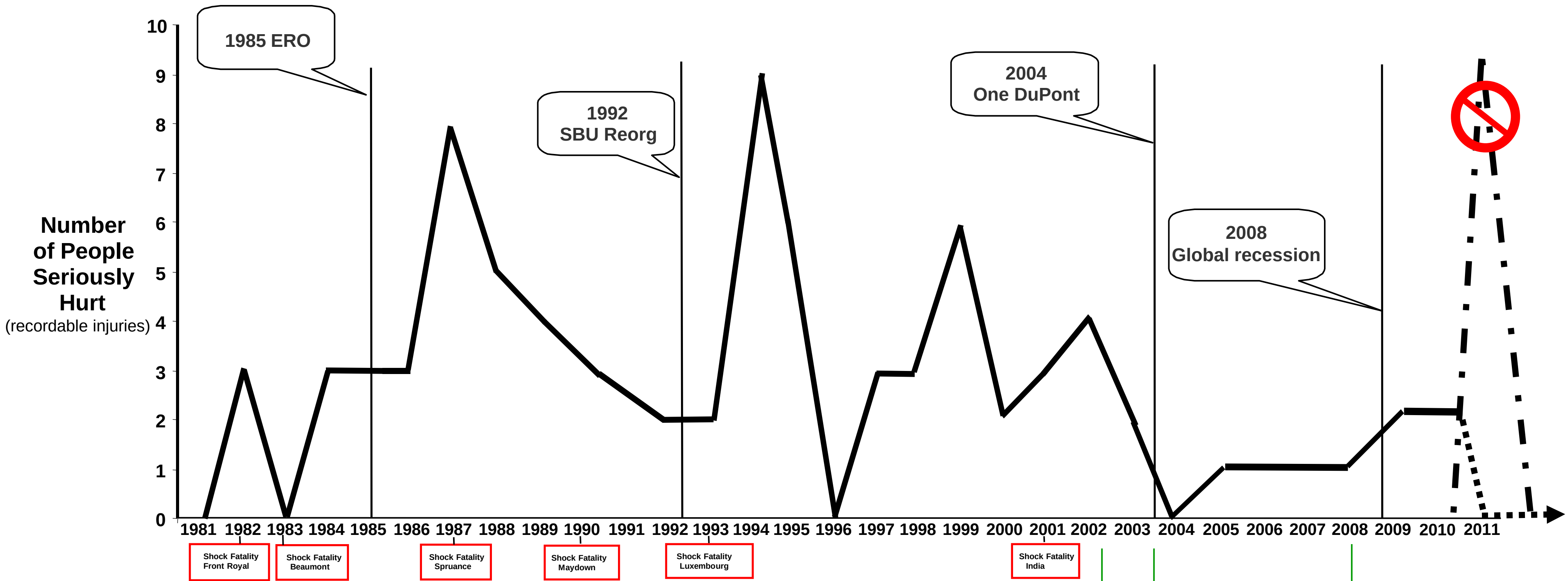
Example: Smart motor control centers

Smart MCC troubleshooting

Traditional troubleshooting

DuPont Electrical Safety *The Path to ZERO*

(employees and contractors)



Recordable Electrical Shock and Arc Flash Injuries
(**Does not include injuries from fire or explosion from electrical energy ignition)**

Goal performance

Events with Corporate-wide implications for Management of Change - Personnel

Fatal injury from contact with electrical energy

Electrical Safety Management Implementation (background in Notes view)

Electrical Safety Management Implemented
- Corporate SHE standard S31G
- 2nd Party SHE audit enhanced

Operations SHE organization restructured
- Electrical safety champions and resources embedded in Operations.
- Corporate Electrical Safety Team rechartered.

S31G revision issued Apr 2008
- Enhanced accountability
- Inherently safer technology
- Clarification of ZERO tolerance for exposure to lethal hazards

Paper presentation at 2013 IAS Petroleum and Chemical Industry Conference - Chicago

Creating a Continuous Improvement Environment for Electrical Safety

Bruce C. Cole, Richard L. Doughty, *Senior Member, IEEE*, H. Landis Floyd, *Senior Member, IEEE*, Ray A. Jones, *Senior Member, IEEE*, and Charles D. Whelan, *Member, IEEE*

Abstract—Increasing OSHA regulation and industry's desire to reduce accidents, injuries, and related costs has focused interest on improving industrial electrical safety performance. Efforts to improve the safety of personnel exposed to industrial electrical hazards may be considered part of an overall strategy to eliminate defects in manufacturing processes. This paper presents a blue print for strategy, design, and implementation of processes to link electrical safety to total quality improvement. Based on the experiences of E. I. du Pont de Nemours & Co., (hereafter referred to as "the Company"), applied methods, results, and future strategies are discussed. A continuous improvement process is applies to several examples, including the previously published Electrically Hazardous Task Classification Flow Sheet.

I. Introduction

An EARLIER paper [1], "Maintaining Safety Electrical Work Practices In a Competitive Environmental," discussed the theoretical aspects and practical concerns for personal injury and described the significant individual and organizational efforts required to maintain high standards of electrical safety in the climate of increased worldwide competitive pressures. This paper builds upon the lessons learned from that effort and discusses the application of continuous improvement technology in the electrical safety arena.

Creating a continuous improvement environment for electrical safety involves the implementation of process strategies to assure understanding and assimilation of corporate objectives, work processes and personal principles [2]. Safety performance is subset of total quality and is dependent on the elimination of defects in work processes [3].

II. Benefits of an Improved Safety Program

Before a business can successfully embark on a continuous improvement effort, the motivation for improvement must be clearly understood and shared throughout the organization. What value is there in maintaining and improving an electrical safety program? This value must be understood to justify and continue expenditures of time and money for electrical safety programs.

In order for any program to survive in the current environment of cost cutting and reduced overhead, it must provide a benefit to the corporation. When we think of the benefits of a safety program, three categories of benefits come to mind: moral, legal, and economic.

As employees, we should expect to work in an environment where we are safe, where our employer cares about our well-being. A company that provides such a safe work-place is considered to be moral by conforming to what we consider to be good and right. Employees would not care to work for an employer who did not provide such a safe work environment. A corporate safety program is an outward sig[n] that the corporation has a moral conscience [4].

Corporations must also adhere to legal requirements i[mposed] by governmental agencies. In the U.S., the Natio[nal] Electrical Code and OSHA regulations are examples of le[gal] requirements that attempt to regulate behavior in elect[rical] work practices and installations. A safety program that [en]forces these legal requirements is a benefit to the corpora[tion]. The penalties associated with not meeting legal requirem[ents] typically exceed the cost of programs required to [...] compliance.

The economic benefits of a safety program may not [be] widely understood. A safety program typically redu[ces the] following:

- —Workers' compensation costs
- —Injury costs
- —Health care costs
- —Accident investigation costs
- —Property losses
- —Insurance premiums
- —Litigation costs
- —Disability costs
- —Business interruptions

The cost of accidents is typically broken down in[to two cate]gories: direct and indirect. Direct costs are normall[y ...] consist of medical costs, premiums for workers' c[ompensation] benefits, liability costs, and property losses. Indi[rect costs are] not insured and include reduced productivity, s[...] administrative time, and damage to facilities. [...] associated with an accident typically equal or [...] costs.

Paper PID 93–11, approved by the Petroleum and Chemical Industry Committee of the IEEE Industry Applications Society for presentation at the 1992 Petroleum and Chemical Industry Committee Technical Conference. Manuscript released for publication May 27, 1993.

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R. L. Doughty, H. L. Floyd, R. A. Jones, and C. D. Whelan are with I. E. du Pont de Nemours & Co., Newark, DE 19714-6090 USA.

IEEE Log Number 9213421

20 YEARS LATER: CREATING A CONTINUOUS IMPROVEMENT ENVIRONMENT FOR ELECTRICAL SAFETY

Paper No. PCIC-(do not insert number)

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Abstract – This paper discusses demonstrated results from the electrical safety improvement strategy documented in the paper, *Creating a Continuous Improvement Environment for Electrical Safety*, presented at the 1992 IEEE IAS Petroleum and Chemical Industry Conference. Two of the original authors present this follow-up paper with a critique of the continuous improvement strategy outlined in the original paper, and discussion of lessons learned from its implementation. The paper shows how this strategy is aligned with leading edge developments in advanced safety management of hazards with high potential for fatality and includes a discussion on applying this strategy to these other hazards.

Index Terms — electrical safety, safety management.

I. INTRODUCTION

In 1989 the management of a global science and technology company (referred to as "the company") made a highly visible commitment to reduce the likelihood and severity of injuries to employees and contractors from electrical hazards. Goals for sustainable improvement were established, financial support provided and dedicated people empowered to reduce the likelihood of electrical incidents, injuries and fatalities, with the intent to accomplish a step change in electrical safety performance, as was done in the mid-1950s. At that time the company had taken action to eliminate the practice of working on energized circuits, which was commonplace in the early days of industrial electrification [1].

In 1990 and 1992, several leaders in the company's electrical safety improvement initiative collaborated on two award-winning papers presented at the annual IEEE IAS Petroleum and Chemical Industry Conference and subsequently published in *IEEE Transactions on Industry Applications*. The first paper, *Maintaining Safe Electrical Work Practices in a Competitive Environment* was presented at the 1990 IEEE IAS Petroleum and Chemical Industry Conference in Houston, Texas. This paper described the company's concern for improving electrical safety performance and the creation of an organizational infrastructure to enable and support changes to better manage electrical hazards in company facilities and operations [2].

The second paper, *Creating a Continuous Improvement Environment for Electrical Safety*, was presented at the 1992 conference in San Antonio, Texas [3]. This paper outlined a strategy for establishing a culture for long term continuous improvement in electrical safety. The elements of that strategy, shown in Fig. 1, describe an organizational culture intent on long term impact on preventing electrical incidents and injuries.

- Understand the business consequences of electrical incidents
- Engage all employees
- Stimulate near miss reporting
- Apply quality improvement model – Plan Do Check Act
- Build networks
- Challenge accepted practices
- Improve collaboration among management, electrical experts and safety professionals
- Use standards as tools
- Promote prevention by design
- Address life cycle: design, construct, operate, maintain, dismantle

Fig. 1 Elements of the strategy described in the paper, *Creating a Continuous Improvement Environment for Electrical Safety* [3]

The culture and continuous improvement strategy described in these papers and nurtured for more than 20 years has resulted in significant improvement in reducing severity and frequency of electrical injuries in the company. Most dramatic is the impact on the frequency of fatalities from electrical energy. As shown in Fig. 2, prior to 1993, fatalities from electrical energy were occurring on average every 33 months. The chart in the figure represents a global work force of employees and contractors that ranged from 80,000 to 120,000 during this period. Since 1993 and through the submission of this paper in 2012, there have been zero fatalities in company facilities.

Trends in Electrocution Fatalities in DuPont Facilities
Employees and Contractors

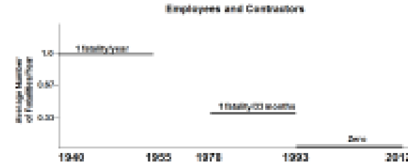


Fig. 2 Trends in employee and contractor electrocution fatalities in example company's facilities worldwide

The electrical hazards have not gone away, and if anything the potential for exposure to hazardous electrical energy has increased due to dependence on electrical technologies for energy, control and communications in industrial applications. What changed was the shift in the electrical safety culture driven by the continuous improvement environment.

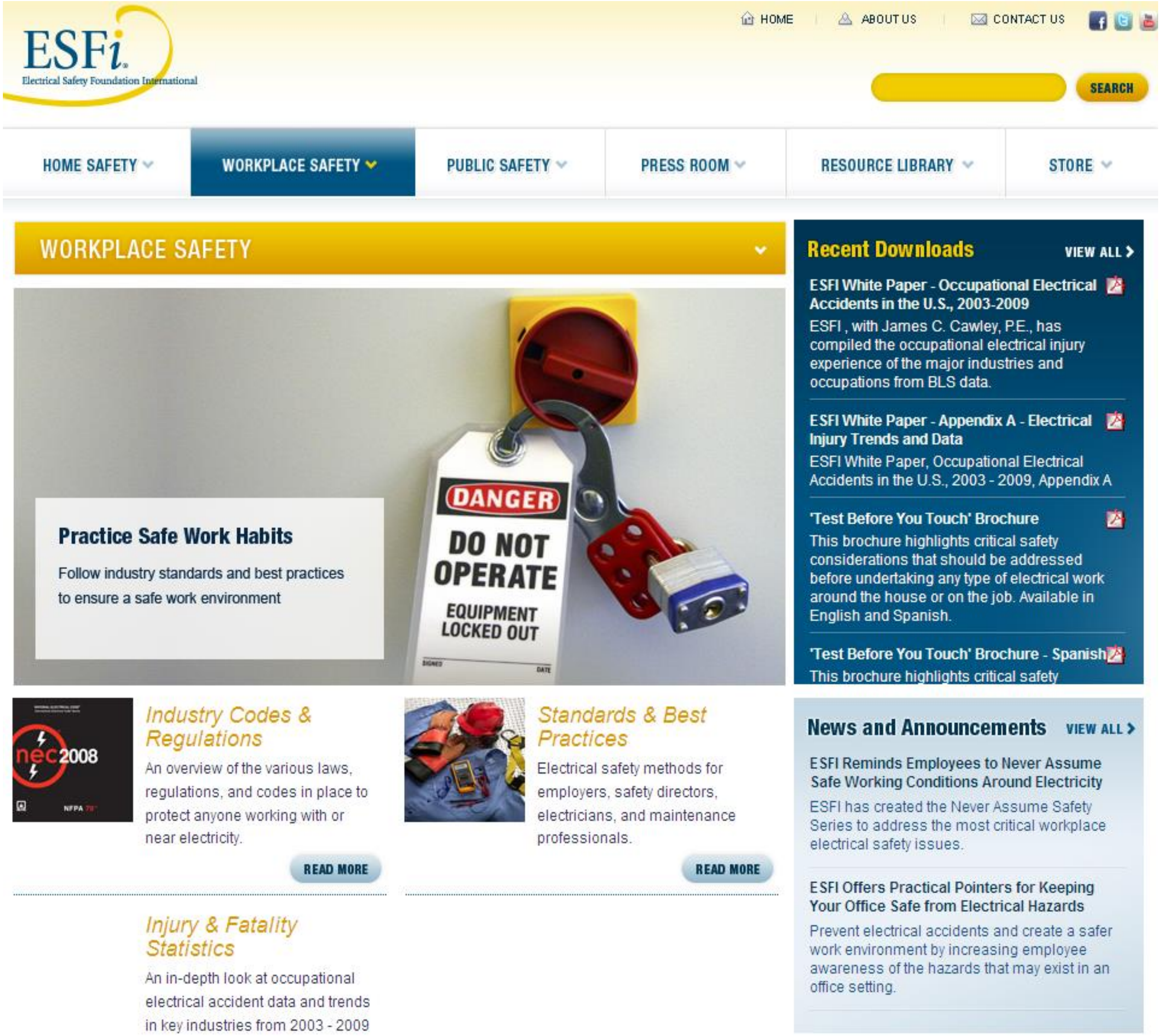
Summary

1. Significant improvement in preventing electrical injuries and fatalities is possible
2. It is not just one standard
3. A robust management system is essential for sustainable and continuous improvement


The Goal is ZERO

ESFi

Electrical Safety Foundation International


ESFi
Electrical Safety Foundation International
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CONTACT US
SEARCH
HOME SAFETY
WORKPLACE SAFETY
PUBLIC SAFETY
PRESS ROOM
RESOURCE LIBRARY
STORE
WORKPLACE SAFETY
DANGER
DO NOT OPERATE
EQUIPMENT LOCKED OUT
Practice Safe Work Habits
Follow industry standards and best practices to ensure a safe work environment
Recent Downloads
VIEW ALL
ESFI White Paper - Occupational Electrical Accidents in the U.S., 2003-2009
ESFI , with James C. Cawley, P.E., has compiled the occupational electrical injury experience of the major industries and occupations from BLS data.
ESFI White Paper - Appendix A - Electrical Injury Trends and Data
ESFI White Paper, Occupational Electrical Accidents in the U.S., 2003 - 2009, Appendix A
'Test Before You Touch' Brochure
This brochure highlights critical safety considerations that should be addressed before undertaking any type of electrical work around the house or on the job. Available in English and Spanish.
'Test Before You Touch' Brochure - Spanish
This brochure highlights critical safety
nec 2008
Industry Codes & Regulations
An overview of the various laws, regulations, and codes in place to protect anyone working with or near electricity.
READ MORE
Standards & Best Practices
Electrical safety methods for employers, safety directors, electricians, and maintenance professionals.
READ MORE
Injury & Fatality Statistics
An in-depth look at occupational electrical accident data and trends in key industries from 2003 - 2009
News and Announcements
VIEW ALL
ESFI Reminds Employees to Never Assume Safe Working Conditions Around Electricity
ESFI has created the Never Assume Safety Series to address the most critical workplace electrical safety issues.
ESFI Offers Practical Pointers for Keeping Your Office Safe from Electrical Hazards
Prevent electrical accidents and create a safer work environment by increasing employee awareness of the hazards that may exist in an office setting.

A new resource – available at no cost!

An online self assessment of <u>*your*</u> electrical safety program

ESFi

Electrical Safety Foundation International

www.esfi.org

How Do You Know? Program

- **Created to raise awareness of and build value for electrical safety auditing**
- **Provides a three-step process for increasing awareness:**
  Step 1: Awareness
  Step 2: Assessment
  Step 3: Improvement

ESFi
Electrical Safety Foundation International

Step 1: *Awareness*
Videos

Raise electrical safety awareness at all levels

- **Highlight critical importance of electrical safety**
- **Introduce concept of auditing/assessment**
- **Provide personal perspectives**

Step 2: *Assessment*

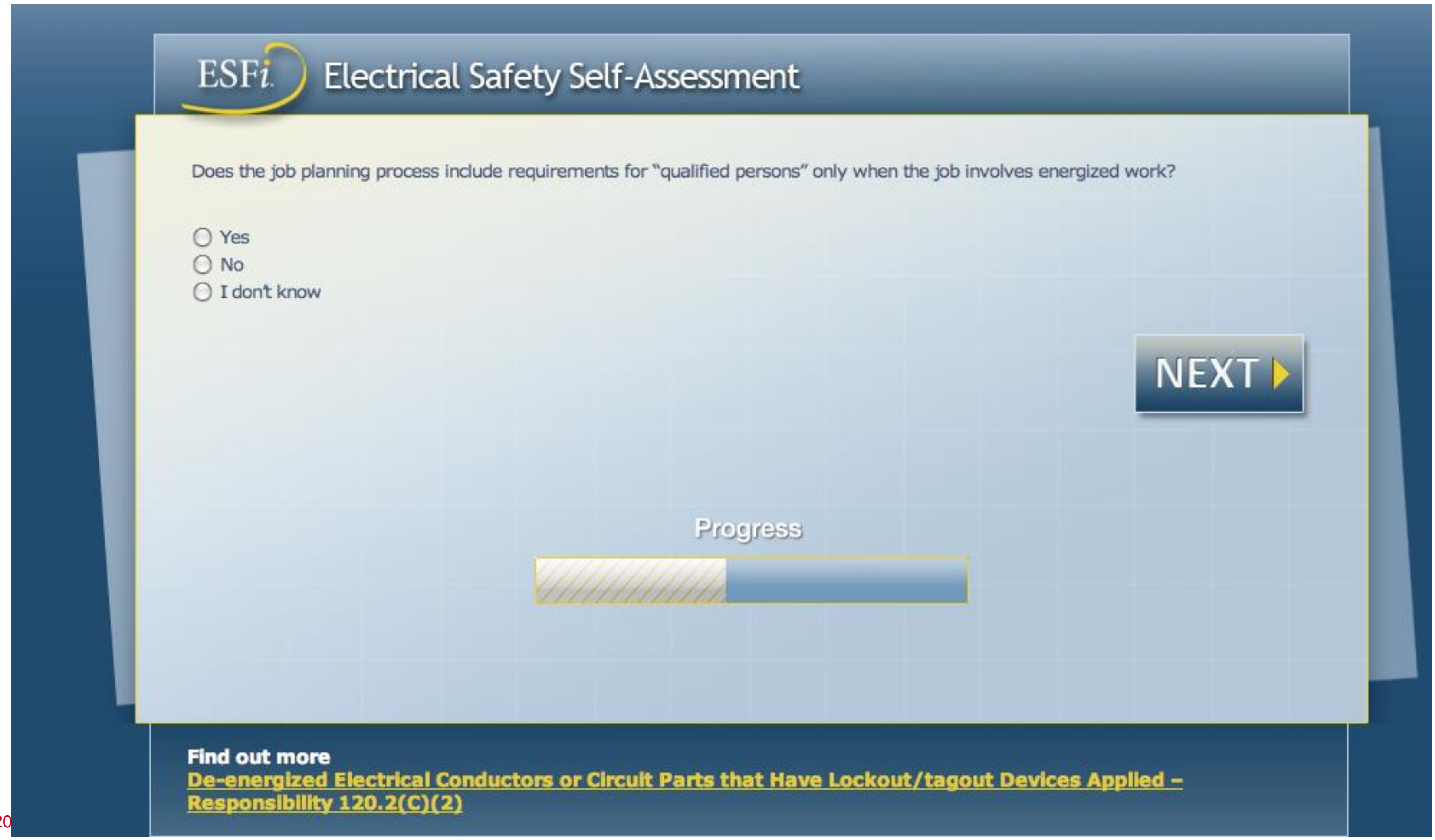
Online Electrical Safety Self-Assessment

- Helps review/analyze electrical safety practices

- Includes questions related to:
  - Facilities
  - Personnel
  - Procedures

- Provides a report of suggested areas for review and/or improvement

Self Assessment Questions



Informational Links

ESFi Electrical Safety Self-Assessment

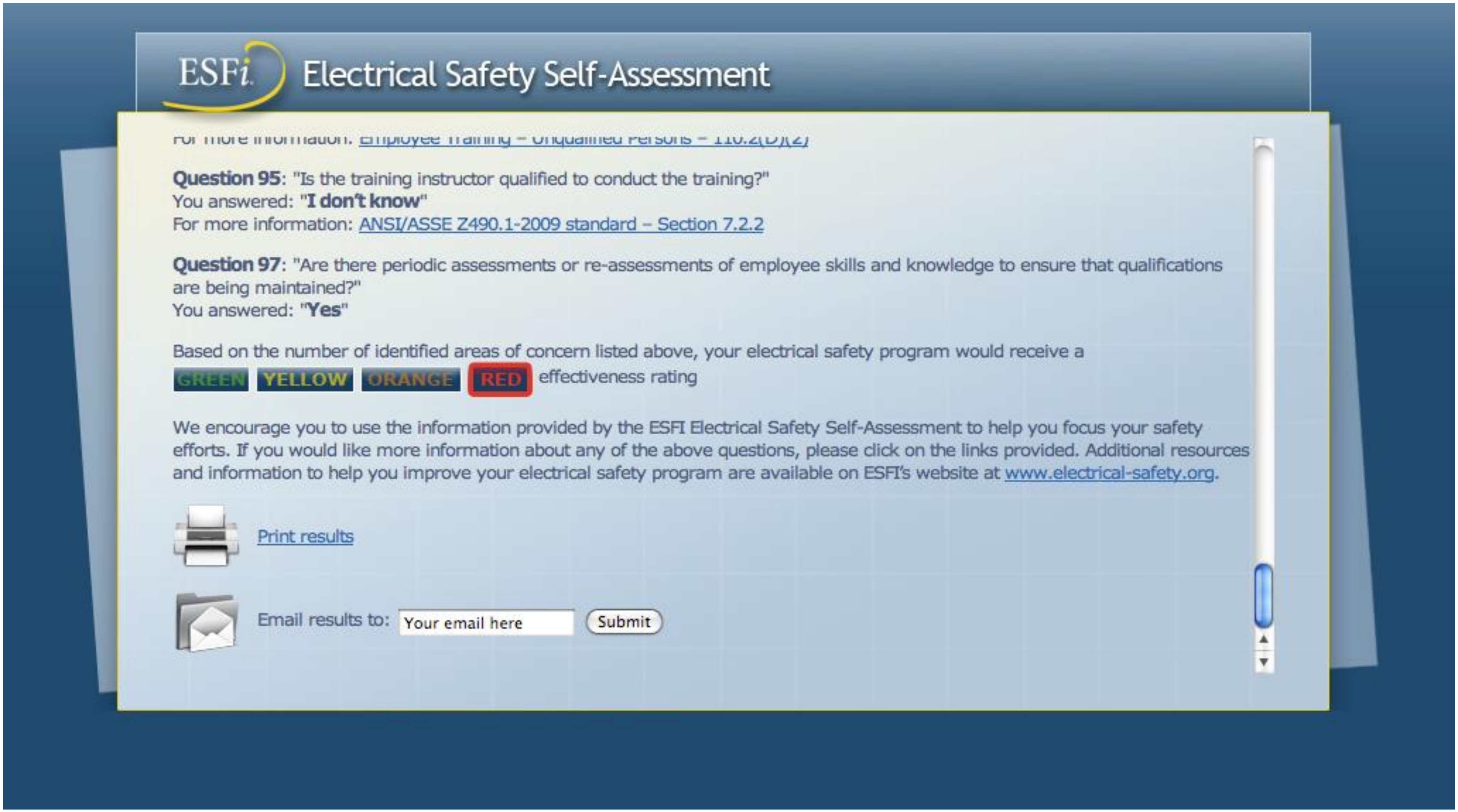
Process of Achieving an Electrically Safe Work Condition – 120.1

If an electrically safe work condition exists, no electrical energy is in the immediate vicinity of the work task(s). All danger of injury from an electrical hazard has been removed, and neither protective equipment nor special safety training is required.

An electrically safe work condition does not exist until all of the six steps in 120.1 have been completed. Until then, employees could contact an exposed live part, and they must wear appropriate PPE.

Visit NFPA's website for more information or to purchase the latest edition of NFPA 70E.
http://www.nfpa.org/aboutthecodes/aboutthecodes.asp?docnum=70e

Results


ESFi
Electrical Safety Self-Assessment
Question 95: "Is the training instructor qualified to conduct the training?"
You answered: "I don't know"
For more information: ANSI/ASSE Z490.1-2009 standard – Section 7.2.2
Question 97: "Are there periodic assessments or re-assessments of employee skills and knowledge to ensure that qualifications are being maintained?"
You answered: "Yes"
Based on the number of identified areas of concern listed above, your electrical safety program would receive a
GREEN
YELLOW
ORANGE
RED
effectiveness rating
We encourage you to use the information provided by the ESFI Electrical Safety Self-Assessment to help you focus your safety efforts. If you would like more information about any of the above questions, please click on the links provided. Additional resources and information to help you improve your electrical safety program are available on ESFI's website at www.electrical-safety.org.
Print results
Email results to:
Your email here
Submit

Step 3: *Improvement*

- **Self-Assessment results provide a starting point**
- **Code & Standard references included**
- **ESFI workplace safety resource library**
- **Audit follow-up support available from:**
  - **3rd party, independent contractors**
  - **Manufacturer or distributor partners**
  - **OSHA VPP Program**

Advancements in the Practice of Electrical Safety

Objectives:

1. **You will gain knowledge that will help enhance support for your electrical safety efforts**
2. **You will gain knowledge on who is most at risk for electrical injury**
3. **You will gain knowledge on how to focus maintenance to help assure reliability of equipment critical to electrical safety**
4. **You will see that significant improvement in electrical safety performance is achievable**

Advancements in the Practice of Electrical Safety

IEEE Southern Alberta Section IAS-PES Chapter

May 13-14, 2013

Lanny Floyd, PE, CSP, CMRP, Fellow IEEE
Principal Consultant, Electrical Safety & Technology
Global Electrical Safety Competency Leader
Email: H-Landis.Floyd@dupont.com
Phone: 302-999-6390

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Questions?