Advancements in the Practice of Electrical Safety
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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

![Graph showing trends in electrocution fatalities]

**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”

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

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 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.

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 fatality 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.2 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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Burn injuries

ABSTRACT

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

more than 70% reduction in electrical fatalities


Injury Facts

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

Number of Injuries (Thousands)

- Construction: 2,610, 3,440
- Manufacturing: 2,440, 1,050
- Utilities: 210, 650
- Professional and business services: 870, 430
- Leisure and Hospitality: 1,610, 270
- Retail trade: 1,120, 220
- Education and health services: 1,240, 240
- Wholesale trade: 570, 130
- Other: 120, 120

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

Electrical Fatalities by Industry Group as a Pct. of Total Electrical Fatalities, 2003-2010

“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

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

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Liberty Mutual Research Institute for Safety, Dedham, Massachusetts

INTRODUCTION

Electrical injuries are a leading cause of work-related fatalities in the United States, and according to recent data from the U.S. Bureau of Labor Statistics (BLS), the number of occupational fatalities in 2017 was higher than in previous years. In fact, electrical injuries were the leading cause of all fatal injuries on the job in 2017, surpassing falls from heights.

In a study conducted by Liberty Mutual Research Institute for Safety in 2018, they found that electrical injuries are more common than many expected, and that a significant number of these injuries occur in the construction industry. In fact, the study found that electrical injuries are responsible for 10% of all workplace injuries.

The study identified several factors that contribute to electrical injuries on the job, including lack of proper training, inadequate safety equipment, and failure to follow established safety procedures. The study also highlighted the importance of implementing effective safety measures to prevent electrical injuries.

The study’s findings have important implications for workplace safety and health, as well as for the broader public health community. Electrical injuries are a serious occupational hazard, but they can be prevented with proper training, equipment, and procedures.

REFERENCES


Enabling Fact Based Decisions

Fatal Occupational Electrocutions in the United States  

Includes in depth analysis of fatalities by workplace scenarios
GFCI Impact on Electrocutions Associated with Consumer Products

The graph illustrates the impact of GFCIs on the number of electrocutions. The data shows a significant decrease in electrocutions as the number of GFCIs increased. This trend is evident from 1970 to 2000, with a notable drop in electrocutions following the widespread adoption of GFCIs.
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 Fatalities in DuPont 1968 - 2011

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

7 out of 12 were not in electrical crafts

Electrical workers

Other workers
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 best friend in the whole world ... and that is never going to change."
Percentage of Non-Fatal Injuries, by Injury Type

- Sprains, strains, tears
- Musculoskeletal disorders
- Falls on same level
- Struck by object
- Falls to lower level
- Assault/Violent act by person
- Highway accidents
- Assault/Violent act by animal
- Fires and explosions
- Electrical shock and burn

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
Percentage of Non-Fatal Injuries, by Injury Type

- Sprains, strains, tears
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- Highway accidents
- Assault/Violent act by animal
- Fires and explosions
- Electrical shock and burn

Lost Time Injuries in the U.S. 2010 BLS Data
**Frequency ≠ Severity** (US OSHA Data)

<table>
<thead>
<tr>
<th>Event or Exposure</th>
<th>No. Fatalities 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>4,547</td>
</tr>
<tr>
<td>Transportation.</td>
<td>1,519</td>
</tr>
<tr>
<td>excludes water, rail, air</td>
<td></td>
</tr>
<tr>
<td>Assaults and violent acts</td>
<td>808</td>
</tr>
<tr>
<td>Falls</td>
<td>635</td>
</tr>
<tr>
<td>Struck by object or equipment</td>
<td>402</td>
</tr>
<tr>
<td>Caught in or compressed by equipment</td>
<td>224</td>
</tr>
<tr>
<td>Exposure to harmful substance or environment</td>
<td>246</td>
</tr>
<tr>
<td>Contact with electric current</td>
<td>163</td>
</tr>
<tr>
<td>Aircraft</td>
<td>151</td>
</tr>
<tr>
<td>Caught in or crushed by collapsing materials</td>
<td>91</td>
</tr>
<tr>
<td>Water vehicle</td>
<td>52</td>
</tr>
<tr>
<td>Explosions</td>
<td>78</td>
</tr>
<tr>
<td>Railway</td>
<td>44</td>
</tr>
<tr>
<td>Other</td>
<td>134</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Event or Exposure</th>
<th>LTI / Fatality Ratio*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fires &amp; Explosions</td>
<td>12</td>
</tr>
<tr>
<td>Contact with electricity</td>
<td>13</td>
</tr>
<tr>
<td>Transportation accidents</td>
<td>23</td>
</tr>
<tr>
<td>Assaults &amp; violent acts</td>
<td>28</td>
</tr>
<tr>
<td>Fall to a lower level</td>
<td>104</td>
</tr>
<tr>
<td>Exposure to harmful substance or environment</td>
<td>107</td>
</tr>
<tr>
<td>Caught in, compressed or crushed</td>
<td>134</td>
</tr>
<tr>
<td>Struck by object</td>
<td>323</td>
</tr>
<tr>
<td>Falls on same level</td>
<td>2,056</td>
</tr>
<tr>
<td>Struck against object</td>
<td>8414</td>
</tr>
<tr>
<td>Slips or trips without fall</td>
<td>12,983</td>
</tr>
<tr>
<td>Overexertion in lifting</td>
<td>14,033</td>
</tr>
</tbody>
</table>

**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

- 0.16% of Lost Time Injuries are from electrical contact\(^1\)
- 3.6% of occupational fatalities\(^1\)
- 7\(^{th}\) leading cause of occupational fatality\(^1\)
- 1-2% of total injuries, but 28-52% of total medical costs\(^2\)
  (study of one utility)
- 2\(^{nd}\) most costly workers comp claim\(^3\)

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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. $\frac{1}{2}$ of the electrical fatalities are not electricians and linemen
Standards

- Role, Limitations and upcoming changes
- Prevention through Design
- Maintenance & Reliability
- Safety Management Systems
Operations and safety for electrical power systems

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


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.
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
110.7 Electrical Safety Program

FPN 1: Safety–related work practices are just one component of an overall electrical safety program.

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 framework 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
- Learn from experience
- Measure it and check results against expectations
- Decide what to do
- Identify how you will know if it worked
- Do what you planned

5/14/2013
Hazard Control Measures

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
Hazard Control Measures outlined in ANSI Z10

- Elimination
- Substitution
- Engineering Controls
- Warnings
- Administrative Controls
- PPE

Addressed in 70E & Z462 Tables

An effective electrical safety program incorporates all 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?
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

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
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
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
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.
Safety-Related Maintenance

The installed fuse must 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
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
Creating a Continuous Improvement Environment for Electrical Safety

Bruce C. Cole, Richard L. Dougherty, Senior Member, IEEE, H. Linda Floyd, Senior Member, IEEE, K. D. A. Jones, Senior Member, IEEE, and Charles D. Wadman, Member, IEEE

I. INTRODUCTION

An older paper (1), "Maintaining Safety: Electrical with Training in a Competitive Environment," discussed the electrical aspects and practical concepts for personnel training and described the multifaceted 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 examines the application of continuous improvement technology to the electrical safety area.

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

II. REASONS FOR AN IMPROVED SAFETY PROGRAM

Before & Berenstein can successfully embark on a continuous improvement effort, the motivation for improvements must be clearly understood and shared throughout the organization. One key value is to move from maintaining and improving on electrical safety programs. This value must be understood to justify and continue expenditure of time and money for electrical safety programs.

In order for any program to survive in the current environment of cutbacks 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:

1. safety benefits
2. legal benefits
3. economic benefits

As employers, we should expect to work in an environment where we are safe, where our employees value our work environment. A company that provides such a safe workplace is considered to be normal by contrasting to what we consider to be the good and right. Employees would not risk to work for an employer who did not provide such a safe work environment. A corporate safety program is an important sign that the corporation has a moral responsibility (4).

Programs 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 processes and installations. Safety programs, that comply with these legal requirements is a benefit to the corporation.

(5) The penalties associated with not meeting legal requirements or not following company procedures required to meeting compliance.

The corporate 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 damage
- Insurance premiums
- Litigation costs
- Downtime costs
- Business interruption costs

The cost of accidents in the utility business derive from two categories, direct and indirect. Direct costs are normally costs of medical care, productivity, wages and property damage. Indirect costs are not insured and include reduced productivity, schedule delays and damages to equipment. Indirect costs associated with an accident typically equal or exceed direct costs.

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

Average Number of Fatalities/Year

<table>
<thead>
<tr>
<th>Year</th>
<th>1940</th>
<th>1955</th>
<th>1978</th>
<th>1993</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>1.0</td>
<td>0.67</td>
<td>0.33</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**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

Screen shot from video “Staged Test Increase Arc Flash Awareness”, IEEE

Courtesy DuPont
Engage all employees

1989 - DuPont

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 an 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
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.
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.)
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.
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!
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)

![Graph of Electrical Safety Management Implementation](image)

**Electrical Safety Management Implementation** (background in Notes view)
- 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.

- Enhanced accountability
- Inherently safer technology
- Clarification of ZERO tolerance for exposure to lethal hazards

**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

5/14/2013
Creating a Continuous Improvement Environment for Electrical Safety

I. INTRODUCTION

Creating a continuous improvement environment for electrical safety involves the implementation of process strategies that ensure understanding and orientation of corporate attitudes, values, policies, and procedures throughout the organization. A safety program must be structured to operate in a way that encourages and supports continuous improvement in electrical safety.

II. BENEFITS OF AN IMPROVED SAFETY PROGRAM

A. Improved worker performance
B. Improved work environment

III. IMPLEMENTATION STRATEGIES

A. Management involvement
B. Employee participation

IV. CONCLUSION

In summary, creating a continuous improvement environment for electrical safety requires a strategic approach that fosters a culture of safety excellence, continuous learning, and improvement. By integrating sound practices and ongoing training, organizations can achieve higher levels of safety performance and reduced incidents.
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
Practice Safe Work Habits
Follow industry standards and best practices to ensure a safe work environment.

Industry Codes & Regulations
An overview of the various laws, regulations, and codes in place to protect anyone working with or near electricity.

Standards & Best Practices
Electrical safety methods for employers, safety directors, electricians, and maintenance professionals.

Injury & Fatality Statistics

Recent Downloads
- ESFI White Paper - Occupational Electrical Injury Trends and Data
- "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.

News and Announcements
- 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 your electrical safety program

ESFi
Electrical Safety Foundation International

www.esfi.org

How Do You Know...
...if your workforce is properly protected from electrical hazards?
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
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

Does the job planning process include requirements for “qualified persons” only when the job involves energized work?

- Yes
- No
- I don’t know

Progress

Find out more:
De-energized Electrical Conductors or Circuit Parts that Have Lockout/tagout Devices Applied - Responsibility 120.2(C)(2)
Informational Links

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.

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http://www.nfpa.org/aboutthecodes/aboutthecodes.asp?docnum=70e

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Results

ESFi Electrical Safety Self-Assessment

For More Information: Employee Training - Unqualified Persons - I10.2(D)(12)

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 effectiveness rating

GREEN YELLOW ORANGE RED

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.
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

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Phone: 302-999-6390

Questions?