Recommendations of the NFPA 70E Future Directions Task Group

April 2004

Table of Contents

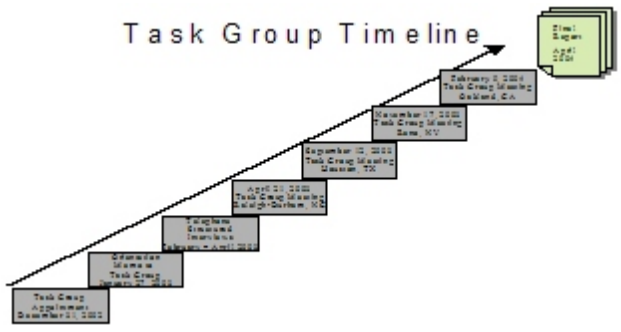
FOREWORD

This report was developed by the NFPA 70E Future Directions Task Group, an appointed panel of experts in fields related to electrical safety in the workplace, and other interested parties in industry and government. The fields of expertise brought to the Task Group include engineering, education, electrical incident prevention, management, medicine, occupational safety, product safety and testing, statistical analysis, insurance, as well as electrical failure origin and cause investigation.

The Task Group Mission was assigned by NFPA 70E Technical Committee Chair, Ray Jones as follows:

- Identify electrical hazards by considering injuries that are associated with an electrical energy source.
- Identify electrical safety issues that are not now addressed by the standard.
- Identify new protective strategies.
- Identify information feedback opportunities.
- Provide guidance about how to improve the effectiveness of the standard.

The Task Group reviewed electrical injury and fatality statistics available through published sources. This information is included in the Appendix to this Report. The Task Group Mission did not include making proposals to standards or regulations, participation in electrical incident investigations, or carrying out recommendations. It was rather to convene respected experts with diverse perspectives in geographic locations across the United States to give its recommendations the greatest leverage. The Task Group was appointed December 31, 2002. An orientation memo began the Task Group's work using a modified Delphi process on January 28, 2003. Subsequently, meetings were held in Raleigh-Durham, North Carolina; Houston, Texas; Reno, Nevada; and Oakland, California.



Task Group members and participants have contributed generously to produce this work. Their volunteer time and energy are greatly appreciated.

NFPA 70E Future Directions Task Group
Final Membership

Task Group Chair
Mary Capelli-Schellpfeffer
CapSchell, Inc.

Allen Bingham
Bingham Consultants

Gibeon Bradbury
Bradbury Technologies

D. Ray Crow
DRC Consulting

Paul Dobrowsky
Eastman Kodak Company

Tom Neal
Neal Associates, Ltd.

David Pace
Olin Corporation

Jack Wells
Pass & Seymour / Legrand

James White
Shermco Industries, Inc.

NFPA 70E Technical Committee Chair
Ray A. Jones
ESCS, Inc.

NFPA 70E Secretary
Ken Mastrullo
NFPA

Recommendations of the NFPA 70E Future Directions Task Group

I. Introduction

This is the final report of the NFPA 70E Future Directions Task Group. It reviews issues relevant to future development of *NFPA 70E Standard for Electrical Safety in the Workplace* subsequent to its 2004 Edition and presents recommendations on these issues.

NFPA 70E Standard for Electrical Safety in the Workplace (NFPA 70E) is the national standard for electrical safe work practices in the United States. It represents the state of the art, and using a consensus process, continues to regularly adapt new knowledge, techniques, and strategies into a comprehensive ANSI standard document.

Electrical safety comprises a wide range of activities addressing electrical and other hazards associated with electrical energy generation, transmission, distribution, and use. Electrical safety aims to prevent electrical failures, and to mitigate failure consequences, especially with regard to injuries and fatalities. Electrical safety principles can be applied to reduce the future costs of electrical failure events, human and operational losses, and regulations.

Traditionally, most occupational electrical safety has been focused on employee performance aspects, as well as personal protection strategies, while emphasizing employer compliance with regulations, codes, and standards.

Resource allocation to occupational electrical safety tends to expand following electrical failures, in particular when property, operational uptime, or personnel are affected. Often resources assigned to “root cause failure analysis” or other forms of “accident investigation” continue for extended periods after an electrical failure. Findings of these failure analyses and accident investigations may be limited or local in their applicability, and may not be readily reconciled within broader community, state, and Federal regulatory contexts, given privacy and litigation issues.

Despite extensive analyses and investigations of workplace electrical events, data collected nationally seldom include details relating to the reasons for occupational electrical failures. Instead, reporting is systematically collected around injuries and fatalities. As a result, generally, occupational statistics used as the basis developing or changing electrical safety standards are limited in scope by the employers represented and number of employees covered by Federal and State reporting mandates.

Injury and fatality data collected identify electrical event cause or coded exposure, industry sector, and body part affected. Causes are characterized according to the US Bureau of Labor Statistics (BLS) guidelines for Occupational Safety and Health (OSH) record-keeping. Record-keeping accuracy is a function of interpretation of the BLS guidelines, employers' techniques for determining event cause, and availability of medical information following an event. Healthcare records and coroners' reports may not inform OSH record-keeping, depending on local practices.

Occupational electrical safety focused primarily on employee performance aspects as well as personal protection strategies exists today because the basis for identification of electrical failures has evolved from practical knowledge rather than scientific research. However, since the early1990s, the development of more precise understanding of electrical failures and factors related to electrical events has led many to revisit electrical safety principles. The implementation of electrical safety using multi-disciplinary and cross-functional approaches encompassing design, development, deployment, and maintenance of electrical installations in systems with variable complexity, is emerging.

In this context, electrical hazards are increasingly understood as resulting from more than one cause and/ or effect of an electrical event. As the understanding of electrical failures and the nature of electrical hazards is emerging, there is growing appreciation that electrical events can result from more than one combination of decisions and actions in any installation, leading to the subsequent appreciation that an electrical failure can have more than one "root" in terms of a tree analysis, or "route" in terms of a pathway analysis.

Limits in data availability hamper the development of more economically constructive electrical safety codes, standards, and regulations. More variables than have been previously considered need further investigation if knowledge is to grow on prevention of electrical failures. Yet, technological, scientific, and management strategies to collect needed information are still in early development as organizations grapple with electrical systems complexity.

Evaluation of the positive and negative human, operational, and economic impact of electrical safety approaches depends on the technology, science, and management information reaching a higher level of maturity than typically seen today. In particular, the beneficial effects of specific design recommendations cannot be adequately assessed until equipment design and performance details are considered in tandem with electrical event human factors, injuries, and fatalities.

II. Discussion

To organize the discussion of relevant issues, the Future Directions Task Group has identified broad topics where further development is needed to advance *NFPA 70E.* These are:

- ***Safety and Risk Management***
- ***Audience***
- ***NFPA 70E Content*, Content and Structure**
- ***Engineering, Science, and Technology***

The first topic relates to conceptual and practical use of the terms safety and risk management. The second addresses NFPA 70E audiences to dis-aggregate the intended versus perceived readers and users of the document. The Content, Context and Structure topic discusses the relationship between *NFPA 70E* and NFPA 70, the National Electrical Code. The Engineering, Science, and Technology topics address issues which may be important for future editions of *NFPA 70E*.

For each of these areas, the following topics are addressed:

- **Issue** – a summary statement of the issues discussed.
- **Impact** – significance of the issue's potential impact.
- **Research and Development** – needs and recommendations.
- **Stakeholders** – identification of those groups most likely to benefit from development of the issue.

III. Recommendations

Safety and Risk Management

Issue:
The term "safety" is interpreted in various ways. In many cases there is not a sharp employer, consumer, or user focus understanding to electrical safety. Sometimes electrical safety is not a high priority. Occupational electrical safety can be underfunded in terms of engineering and capital resources. Electrical safety can be ignored for expediency, as suggested by reports of frequent electrical installation, maintenance, and repair work done energized.

"Risk management" is suggested in the question, "If I am working on a piece of equipment rated to the condition, doors closed, shouldn't I be able to do this safely?" The term as used around electrical events suggests looking beyond what is obvious in the report of an electrical event, learning and understanding what could have been done differently; or w hat were the patterns of "why"; or from a view outside the scope of *NFPA 70E*, what happened.

Impact:
Costs of safety and risk management failures in electrical energy generation, distribution, transmission, and use are significant. As background, occupational injury and fatality costs are staggering: US 1990s estimates of roughly $140 billion per year from occupational injuries compare to annual cancer costs at about $170 billion (Leigh *et al., 2004*). An electrical utility industry-sponsored study suggests that 650 electrical injury cases would generate direct and indirect costs of at least $1 billion (Wyzga and Leandroos, 1999). Note in 2001 in the US, contact with electric current resulted in 3,394 *reported* lost time electrical injuries, and hundreds of recognized fatalities. Not even considered in these financial estimates are economic losses with electrical fires, explosions, and economic hardships subsequent to unintentional interruptions in electrical power delivery.

Research and Development:
The terms "safety" and "risk management" differ in their meaning. In Task Group discussions, safety is variably defined. Safety can be a process that protects people from coming between hazard and harm, or injury. Or, safety in general can mean "free of injury" or "protected from harm or injury through knowledge, or through equipment design and installation, at work or other places."

As a term, "risk management" grows from "risk assessment", which focuses on "hazards." Systems approaches to hazards are implied with the use of "management", This implication suggests an employer management infrastructure. However, in field settings, the person doing a task is expected to know and manage the hazards and risk in their task, either as part of the management's system, in addition to management's system, or sometimes in spite of the management's system.

The employer versus employee responsibilities in executing risk management in occupational settings is presently directly addressed in the *NFPA70E*. How these responsibilities contribute to electrical safety is specifically articulated within the concept of an "electrical safety program." Further work is needed to broaden the context of these concepts. Research and development of the distinctions between electrical safety and electrical risk management for use within the text and tables of the *NFPA 70E* is needed.

Stakeholders:
Improved use of safety and risk management terminology particularly affects the worker, employer, regulatory, and manufacturing communities. For the worker doing their job, safety and risk are part of every day. For the employer, these safety and risk influence management systems essential to creating and maintaining occupational and environmental security and reliability during electrical operations. For the regulatory community, improved use of safety and risk management terminology provides a better basis for targeting regulations, inspection, and educational programs and documents.

Audience

Issue:
The *NFPA 70E* document has multiple audiences. The Task Group has identified the intended versus perceived readers of *NPFA 70E* often are not the same people. The Task Group consensus is that the *NFPA 70E* writing is often developed to be accessible for a regulatory community rather than for other audiences.

Impact:
The Task Group notes that to a very large degree, *NFPA 70E* is written for the US Department of Labor Occupational Safety and Health Administration (OSHA). The history of OSHA's initial encouragement of *NFPA 70E* contributes to language choices reflected in the standard's present writing. Also, there is an acknowledged shared belief on the part of the Technical Committee that the use of language consistent with a regulatory style will increase the likelihood of further *NFPA 70E* adoption or reference by OSHA in ongoing rule-making.

These observations suggest that *NFPA 70E* is written more directly to a regulatory audience, rather than to an end-user audience of those who are most likely on a daily basis to need, read, and use the information. This end-user audience includes safety professional writing safety requirements, supervisors, engineers, and electricians.

Competing influences on the *NFPA 70E* readership are appreciated by the Task Group. Understanding reader perceptions of the relative information value of these influences is seen as potentially useful in setting future priorities (Figure 1).

With specific regard to audiences of electricians, the Task Group suggests that there are multiple information sources that electricians may see or experience as their safety resource. The Task Group offers an informal rating of the varied electrician information inputs based on anecdotal assessment of what appears to be the value of information inputs to electricians as "observed". This informal rating is offered in comparison to the informal rating of the value that the Task Group considers might be optimal as "deserved" (Figure 2).

Additionally, the Task Group identifies that new audiences previously not addressed by *NFPA 70E* can greatly benefit from inclusion as readers and users of the *NFPA 70E* document. In this regard, employees working in novel electrical environments, including Department of Energy (DOE), Department of Defense (DOD), US National Laboratories, and Federally funded university and college laboratories are recognized. These electrical environments employ professional and other workers with responsibilities for energized installations. This community may extend to include as many as 20,000 employees in the US DOE laboratories and 50,000 in US DOD laboratories. Estimates of US National Laboratory and academic laboratory employment suggest a number of people employed at a factor of 10 above these approximations.

Research and Development:
The Task Group notes that development of communication strategies tailored to the diverse audiences of *NFPA 70E* is likely to be of high value to the readership. Methods to promote reader characterization and their information relationships as well as changing aspects of the electrical industry environment are needed.

Fundamental research is also needed to address the mitigation of electrical hazards in non-civilian and non-power frequency installations. An example of the kind of question needing an answer in this regard is, “What personal protective equipment (PPE) is needed in a non-power frequency electrical arc hazard scenario?”

Stakeholders:
Extension to new readers can bring the benefits of occupational electrical safety to communities of employees who may not at this time be aware of the nature of the electrical hazards. The stakeholders include electricians, engineers, educators, safety/risk managers, equipment manufacturers, OSHA, employers, operators of equipment, supervisors, contractors, crafts/trades/maintenance employees, and unqualified people who might not even realize how what they are doing for work brings them near an electrical hazard.

NFPA 70E Content, Context, and Structure

Issue:
The content, context, and structure of *NFPA 70E* have to be integrated in a usable way. At the most basic level, readers want to know, "Why do I have to follow this standard?" Set in economic terms**,** the question sometimes becomes, "Why is the standard in the way of getting my job done?"

Impact:
The Task Group emphasizes that for the *NFPA 70E* to be important to the people who are exposed to electrical hazards, it must be usable.

Research and Development:
The following sub-headings indicate specific issues deserving further exploration.

Applicability
Employers and employees continue to be uncertain of the scope of *NFPA 70E.* Often asked is the question, "Does this really apply to me?" Another common question is, "How do I convince management that I have to do more?"

Inspections
A big concern from inspectors is "What do we do?" Their employment situation can be even more precarious than an electrician's. To inspect an installation, inspectors often have to take the cover off equipment. It can be difficult for an inspector to get a contractor to the inspection site to turn off power.

Another issue is around the definition of the inspector's workplace. Does the inspector "work on or near" electrical installations? For that matter, how is the inspector's workplace identified? Identification of who the inspector works for, who is responsible for the inspector's safety, and clearer definition of the content of acceptable inspector tasks is seen as a bridge issue between NFPA 70E and the NEC, which often indicates where inspections are needed. .

Installation profiling
Technical questions relevant to safe electrical work continue to be appreciated through the *NFPA* process. For example, installation profiling: How should this be done? How should it be kept "true" or the information in the profile "evergreen"? What are the labeling logistics? How are installation profiles held by employers integrated with information only available from utility providers?

Personal Protection Equipment (PPE):
Are there better strategies for PPE recommendations? Are there alternatives to tables? Should tables be structured for 90-95% employees working on or near electrical sources, or should the tables address special situations?

Product Standards
The Task Group identifies the relationship between the National Electrical Code in regard to installations and the related product standards as highly influential in the employee experience of electrical safety. However, the linkages between the content of the NEC, and the *NFPA 70E*, in terms of how each of the two documents may compliment or augment the other is not obvious. How are the safety experiences in the workplace connected to product standards?

Usability
Repeatedly through the Task Group's discussions, issues of usability surfaced: How can the document be more user friendly, as some of the pieces are complex? What is the value of the detail? Does detail make people safer? Does more detail cloud what is important? Is the *NFPA 70E* designed to go in an electrician's toolbox?

Stakeholders:
Stakeholders include the standards community, employers, manufacturers, unions, contractors, regulators, educators, risk and legal advisers, and interested readers. Through the NFPA consensus process, stakeholders are expected to advocate for the content, context, and structure in *NFPA 70E* that maximizes their constituencies' utility for the document.

Engineering, Science, and Technology

Issue:
The Task Group identified engineering, science, and technology issues relevant to the NFPA 70E Standard's future development. In response to the question, " What effects of electricity concern you the most?", discussion focused on fire and burns frequently, then electrical shock next.

Additional comments were that we don't have all the information as there is not an incontrovertible data base that can give us a formula for "the way to go." Without well grounded data, the safety factors are moving targets. We need agreement on fundamentals, including arc flash, and the areas we haven't gotten to, like arc blast (Figure 3).

Impact:
Credibility and authority in the NFPA 70E is based on consensus built around engineering, science, and technology knowledge. Because each generation of engineers and scientists re-interpret facts and create new knowledge based on advancing understanding, the NFPA 70E can be expected to inevitably evolve.

Exposure and familiarity drive acceptance and create consciousness of electrical safety. Communication helps convert acceptance and consciousness of electrical safe work practices to adoption through safety rules and procedures, as well as engineering and equipment investments targeted to include electrical safety as a priority.

Research and Development:
Research and development is needed to more fully describe the hazards that attend electrical generation, transmission, distribution and use, and to orient risk assessment of the hazards. All of the effects of electricity–shock, flash, blast–can kill. However, the ability to predict, simulate, or model the worse effect or the effect that is likely to do harm in the situation under study is in earliest stages.

Situational variables affecting hazard severity are not comprehensively understood. Practical safeguarding, installation profiling, and simpler methods for determining needed protection strategies all flow from a more full description of the hazards that attend electrical operations. These questions need to focus continued discussion:

- How can we be better communicate with people concerning electrical safety?
- How can we overcome the reluctance of users or consumers to readily adopt or purchase based on safety?

The basic challenges around how listeners hear and use electrical safety information limit the advance of safe work practices and future implementation of newer technology based approaches. In particular, how evolving physics and engineering

concepts are integrated into economic life has significant potential financial consequences related to speed of integration of new technologies, process innovation around electrical systems design and control, and globalization.

Stakeholders:
The stakeholders in further development of this topic include educators, electricians, engineers, safety/ risk managers, equipment manufacturers, OSHA, and employers who must integrate evolving technologies into the electrical power systems of today.
.
Additional stakeholders are those accountable for the training and safe performance of employees at high risk for occupational electrical injury, including construction workers, young workers, elderly workers, and workers employed in rural locations.

IV. Conclusions

Advances in the *NFPA 70E Standard for Employee Safety in the Workplace* can be anticipated as the issues identified in this report are more fully developed.

Funding of research is needed across broad areas to provide the technical, scientific, and management information necessary to transition electrical safety to a scientific foundation.

Given the scope of issues identified, funding is most likely to require collaboration between stakeholders, including government, manufacturing, engineering, employer, and standards communities.

V. References

Bureau of Labor Statistics. Fatal occupational injuries by event or exposure, 1996 - 2001. Cause of Fatal Occupational Injury (CFOI) statistics retrieved online. 07/25/03 from ftp://ftp.bls.gov/pub/news.release/cfoi.txt . Tables consulted included Table 1, R32, R33, and R63 .

Cawley JT, Homce GT. *J Safety Res* 34(2003): 241-248.

Leigh JP, Marcin JP, Miller, TR. An estimate of the U.S. Government's undercount of nonfatal occupational injuries. *JOEM* 46 (1): 10-18, 2004

NIOSH. *Worker Health Chartbook 2000*, DHHS (NIOSH) Publication No. 2000-127, September 2000, Figure 2-6, p.33

NIOSH. *Worker Death by Electrocution: A Summary of NIOSH Surveillance and Investigative Findings*, DHHS (NIOSH) Publication, 1998, Figure 7, p. 15.

Wyzga R, Leandroos W. Health consequences of global electrification. New York Academy of Sciences (NYAS) Annals, 888: 1-7, 1999.

VI. Figures

The following figures are referenced in the text:

Figure 1.

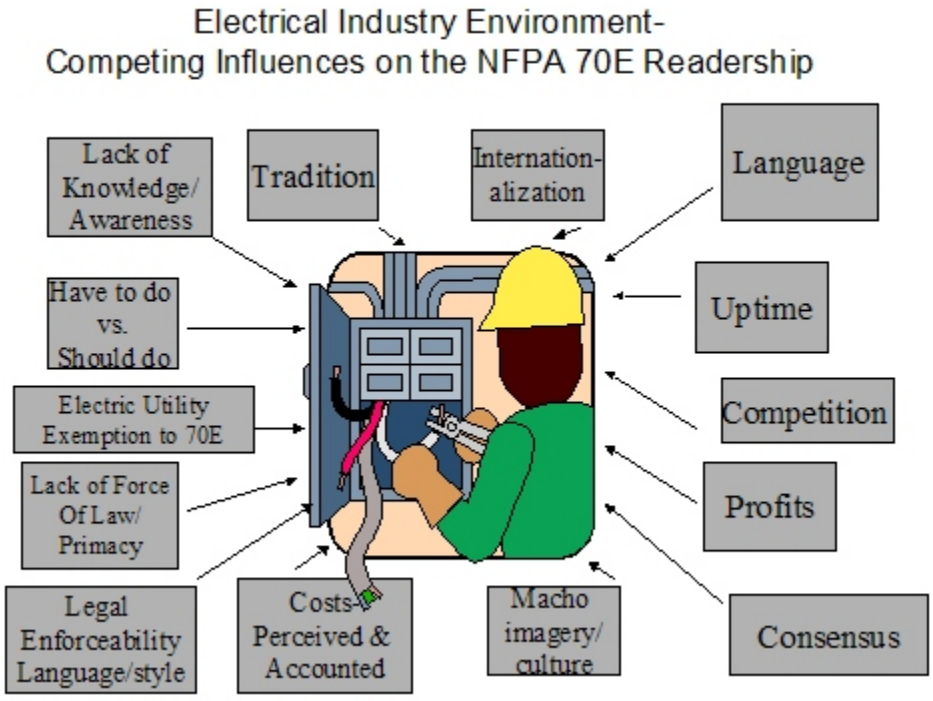

Electrical Industry Environment-
Competing Influences on the NFPA 70E Readership
Lack of Knowledge/ Awareness
Tradition
Internation-alization
Language
Have to do vs. Should do
Uptime
Electric Utility Exemption to 70E
Competition
Lack of Force Of Law/ Primacy
Profits
Legal Enforceability Language/style
Costs-Perceived & Accounted
Macho imagery/ culture
Consensus

Figure 2.

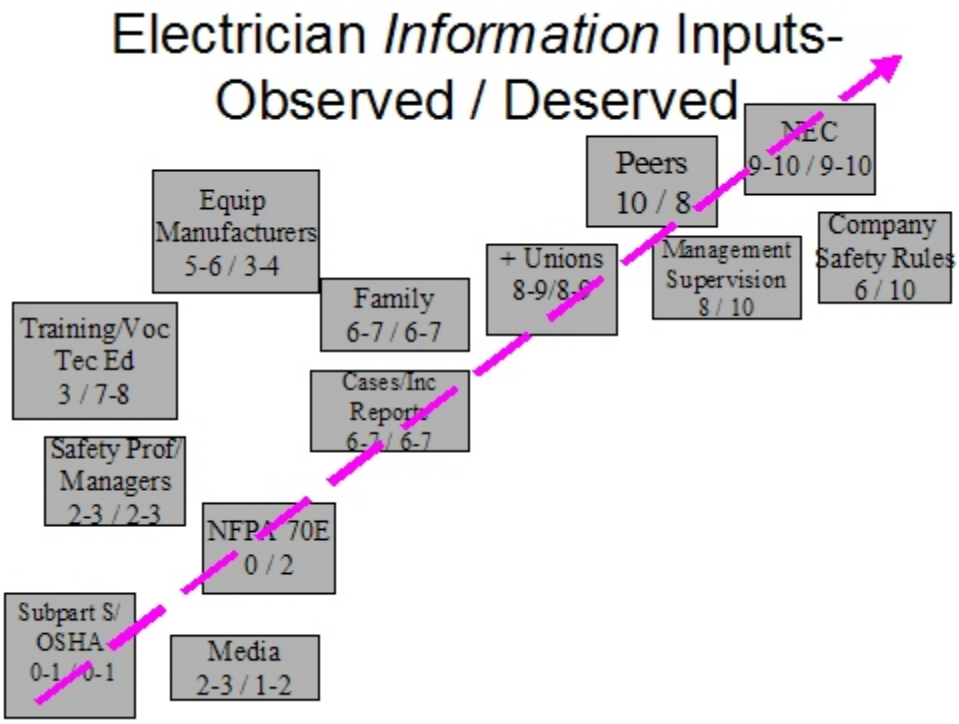
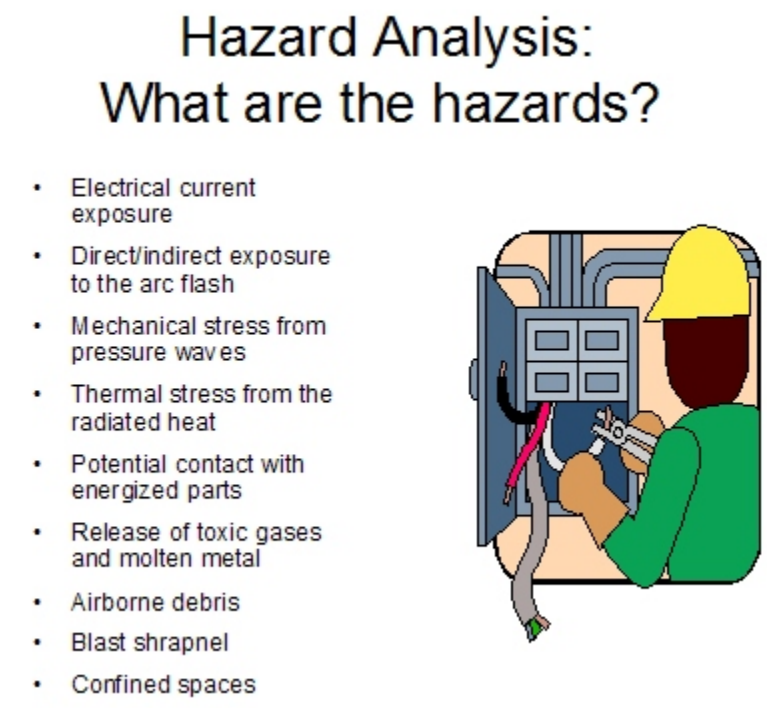

Electrician *Information* Inputs-
Observed / Deserved
Subpart S/
OSHA
0-1 / 0-1
Media
2-3 / 1-2
NFPA 70E
0 / 2
Safety Prof/
Managers
2-3 / 2-3
Training/Voc
Tec Ed
3 / 7-8
Equip
Manufacturers
5-6 / 3-4
Family
6-7 / 6-7
Cases/Inc
Reports
6-7 / 6-7
+ Unions
8-9/8-9
Peers
10 / 8
Management
Supervision
8 / 10
NEC
9-10 / 9-10
Company
Safety Rules
6 / 10

Figure 3.


Hazard Analysis:
What are the hazards?
• Electrical current exposure
• Direct/indirect exposure to the arc flash
• Mechanical stress from pressure waves
• Thermal stress from the radiated heat
• Potential contact with energized parts
• Release of toxic gases and molten metal
• Airborne debris
• Blast shrapnel
• Confined spaces

VII. Appendix

The following slides are illustrations developed by the NFPA 70E Future Direction Task Group during their 2003-2004 meetings. Anne Golding assisted in the slide preparation for Task Group sessions.