

Analyzing Electrical Hazards in the Workplace

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The need for analyzing electrical hazards in the workplace has been recognized by a small segment of the industry for many years. The petrochemical industry and many government institutions have performed research on this subject for over thirty years. For the most part however, the electrical industry, at least at the user level, has largely ignored the subject, essentially reacting to catastrophic accidents rather than proactively trying to predict and prevent them. Recent changes in consensus standards, along with a better general understanding of the seriousness of electrical hazards have resulted in a renewal of interest in the subject. This article will provide an overview of the three principle types of electrical hazard analysis, along with a discussion of the relevant standards and regulations pertaining to the subject.

Shock Hazard Analysis

Each year several hundred workers are killed as a result of inadvertent contact with energized conductors. Surprisingly, over half of those killed are not in traditionally electrical fields (i.e. linemen, electricians, technicians, etc.), but are from related fields such as painters, laborers, and drivers. Recent investigations into the causes of these fatalities point to three principle causal factors:

- Failure to properly or completely de-energize systems prior to maintenance or repair work;
- Intentionally working on energized equipment; and
- Improper or inadequate grounding of electrical system components.

These three factors form the basis for hazard analysis of the electrical shock hazard.

To appropriately assess the electrical shock hazard associated with any type of maintenance or repair work, it is necessary to evaluate the procedures or work practices that will be involved. These practices should be evaluated against both regulatory requirements and recognized good practice within the industry. These principles are summarized below.

Regulatory Requirements

- All equipment must be placed in a deenergized state prior to any maintenance or repair work. (Limited exceptions exist).
- The deenergized state must be verified prior to any work.
- The deenergized state must be maintained through the consistent use of locks and tags, and in some cases, grounding.
- When energized work is performed, it must be performed in accordance with written procedures.

Industry Recognized Good Practices

- Plan every job.
- Anticipate unexpected results and the required action for these results.
- Use procedures as tools.
- Identify the hazards. Keep unqualified workers away from these hazards.

- Assess employee's abilities.

In addition to the assessment of work practices, a shock hazard analysis must include an assessment of the physical condition of the electrical system.

Although the continuity and low resistance of the equipment grounding system is a major concern for reducing the risk of electrical shock, it is not the only one. Of equal importance is to insure that covers and guards are in place; that access to exposed conductors is limited to electrically qualified personnel; and overcurrent protective devices are operable and of appropriate interrupting rating. Even the safest procedures, when performed on poorly constructed or maintained equipment represent a risk to employees.

Arc Flash Hazard Analysis

An estimated 75% to 80% of all serious electrical injuries are related to electrical arcs created during short circuits, ground faults, and switching procedures. In recognition of this fact, standards organizations such as the National Fire Protection Association (NFPA) have provided the industry with better techniques to evaluate both the magnitude of the electrical arc hazard and appropriate protective clothing.

The principle factors used to determine the arc-flash hazard to personnel are as follows:

1. Available short circuit current at the arc location.
2. Duration of the electrical arc.
3. Distance from the arc to personnel.
4. The arc gap.

To accurately assess the arc hazard, and make appropriate decisions regarding personal protective clothing, it is necessary to fully understand the operation of the system under fault conditions. This requires both a short circuit analysis, in all likelihood down to the panel board level, and protective devices coordination study. It is a common misconception that arc hazards are an effect of only high voltage. The actual arc hazard is based on available energy, not available voltage. In certain conditions, a low voltage arc's duration is longer than a high voltage arc. With this information available, the magnitude of the arc hazard at each work location can be assessed using several techniques. These techniques include:

- NFPA 70E, "*Standard for Electrical Safety in the Workplace*"
- IEEE Standard 1584, "*IEEE Guide for Performing Arc-Flash Hazard Calculations*"

Each of these techniques requires an understanding of anticipated fault conditions, and the limitation of the calculation method, both of which are beyond the scope of this article.

The results of the arc-flash hazard analysis are most useful when they are expressed in terms of the incident energy received by exposed personnel. Incident energy is commonly expressed in terms of calories per cm² (cal/cm²). Arc protective clothing is rated in terms of its Average Thermal Performance Value (ATPV), also expressed in terms of cal/cm².

In addition to protective clothing, there are some safe work practices that can be adopted to minimize or eliminate the hazards. These practices include clothing, body positioning, insulated tools; line clearance procedures and other factors must be carefully scrutinized to insure that the risk to employees is minimized.

National Electrical Code Section 110.16 Flash Protection

The NEC states, “*Electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers, that are in other than dwelling units, and are likely to require examination, adjustment, servicing, or maintenance while energized shall be field marked to warn qualified persons of potential electric arc flash hazards. The marking shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.*” Because of the NEC requirements, we can conclude the following:

As with the electrical shock hazard, the easiest and most effective way to mitigate the arc hazard is to completely de-energize the system for any type of maintenance activity.

Arc Blast Hazard Analysis

An electrical blast, or explosion, as it is often termed, is the result of the heating effects of electrical current and the ensuing arc. This phenomenon occurs in nature as the thunder that accompanies lightning, a natural form of an electrical arc.

Unfortunately, little can be done to mitigate the blast hazard, at least in terms of personal protective clothing or equipment. Blast pressure calculations can be used to determine whether enclosures will withstand an internal fault if sufficient manufacturer’s data is available. It may be more important to merely recognize the magnitude of the hazard so that appropriate safety practices, such as correct body positioning can be incorporated into work procedures. If the blast hazard is high, or if it is in a limited space, the blast can severely injure or kill a person. If these conditions are present, serious consideration should be given to not allowing personnel in the area during specific evolutions.

Selection of Electrical Protective Equipment

Most employers, operators, and electricians are knowledgeable in the selection and inspection requirements for electrical PPE used for the prevention of electrical shock hazards, as well as head, eye, hand, and foot protective equipment. All of these requirements are readily found in OSHA 1910, Subpart I, Personal Protective Equipment. Unfortunately, most people have limited knowledge or experience of arc and blast hazards that may be associated with the maintenance and operation of energized electrical equipment and the necessary protective clothing required.

OSHA 1910.132(d) states, “*The employer shall assess the workplace to determine if hazards are present, or are likely to be present, which necessitates the use of Personal Protective Equipment (PPE). If such hazards are present, or likely to be present, the employer shall:*

Select, and have each employee use, the type of PPE that will protect the affected employee from the hazards identified in the hazard assessment.”

OSHA 1910.132 (f) – Training (1) states: “*The employer shall provide training to each employee who is required by this section to use PPE. Each employee shall be trained to know at least the following:*

- *When PPE is necessary;*
- *What PPE is necessary;*

- *How to properly don, doff, adjust, and wear PPE;*
- *The limitations of the PPE; and*
- *The proper care, maintenance, useful life, and disposal of PPE”.*

Included in this hazard assessment should be the three electrical hazards; shock, arc, and blast. OSHA 1910.137 identifies the selection, inspection, and use requirements for electrical PPE. OSHA does not identify specific clothing that should be worn to protect the employee from the arc/flash hazards, but OSHA does specify what type of clothing is prohibited.

1910.269 (l)(6)(ii) requires that *“The employer shall train each employee who is exposed to the hazards of flames or electric arcs in the hazards involved.”* Additionally, 1910.269(l)(6)(iii) states: *“The employer shall ensure that each employee who is exposed to the hazards of flames or electric arcs does not wear clothing that, when exposed to flames or electric arcs, could increase the extent of injury that would be sustained by the employee.”* (This clothing includes natural fibers such as cotton, wool, and silk. Author’s emphasis)

“Note: *Clothing made from the following types of fabrics, either alone or in blends, is prohibited by this paragraph, unless the employer can demonstrate that the fabric has been treated to withstand the conditions that may be encountered or that the clothing is worn in such a manner as to eliminate the hazard involved: acetate, nylon, polyester, rayon.”*

OSHA does, however, require protection from the hazards of electricity in 1910.335(a)(2)(ii) which states: *“Protective shields, protective barriers, or insulating materials shall be used to protect each employee from shock, burns, or other electrically related injuries while that employee is working near exposed energized parts which might be accidentally contacted or where dangerous electric heating or arcing might occur.”*

The consensus standard for determining the necessary clothing and training is NFPA 70E, *Standard for Electrical Safety in the Workplace.*

Summary

In resolving the issues in analyzing electrical hazards in an industry, we must follow a path that will lead to a comprehensive analysis of the problems that exist and provide a quantified value to ensure the selection of appropriate personal protective equipment and clothing. An analysis of all three hazards, shock, arc, and blast must be completed and steps taken to prevent injuries.

The following are steps could be taken to ensure adequacy of the electrical safe work practices program and training of “qualified” electrical personnel:

1. Conduct a comprehensive Job Task Analysis.
2. Complete a Task Hazard Assessment including:
 - a. Shock hazard
 - b. Arc flash hazard
 - c. Arc Blast hazard
 - d. Other hazards (Slip, fall, struck-by, environmental, etc.)
3. Analyze task for the Personal Protective Equipment needed
4. Conduct Training Needs Assessment for Qualified and non-qualified electrical workers
5. Revise, update or publish a complete “Electrical Safe Work Practices Program”

Regulatory agencies and standards organizations have long recognized the need to analyze the hazards of electrical work and plan accordingly to mitigate the hazards. Unfortunately, many in the

electrical industry have chosen to “take their chances”, largely because nothing bad has yet to happen. As more information becomes available on the economic and human costs of electrical accidents, it is hoped that more in the industry will recognize the need for systematic hazard analysis, and an electrical safe work program that emphasizes hazard identification and abatement.

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