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OSHA and NFPA 70

Their Implications on Energized Thermography of Electrical Distribution Systems

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Abstract

Electrical accidents happen daily; however, there are important steps that companies and individuals can take to reduce the occurrence of these accidents and protect everybody concerned from the physical, financial, and statutory consequences. The National Fire Protection Association (NFPA), in its regulation 70E, provides a reference for facilities to meet the requirements of electrical workplace safety and its regulation 70B outlines the best practices for setting up and maintaining and Electrical Preventive Maintenance (EPM) program.

18-1030-0003 Rev. A

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The essential element for electrical safety is to ensure that the equipment is in an electrically safe condition before any work is commenced. NFPA 70E provides additional best practices for electrical safety, and the recommendations of these standards are used by governmental enforcement agencies (such as OSHA), municipal building inspectors and even insurance companies as the basis for mandates being placed on corporations and individuals the world over. This paper will explore the standards and their implications on thermographers and electrical preventive maintenance programs.

INTRODUCTION

NFPA was established in 1896 and is the world's leading advocate of fire prevention. The influence of its 300 codes and standards are evident in buildings, products, and practices throughout the world. NFPA codes are adopted through a broad consensus of experts, and have resulted in some of the world's most referenced and respected codes. NFPA 70, also known as the National Electric Code (NEC) is the standard developed for electrical design, installation and inspection. It does not specifically address electrical maintenance or safe work practices. For the consensus standards on these topics we turn to NFPA 70B and NFPA 70E respectively.

Electrical power is the lifeblood of our everyday needs, dependable electrical power distribution is not an option – it is essential to corporate economic health. Therefore you need to ask the question… Is your electrical maintenance program an overhead or an asset? What would be the consequences to our company or operation if we were to lose electrical power? This is the business case for electrical reliability. What would be the cost to your operation if any of the following occurred? Is your operation at risk for:

- An unannounced disruption of your operations – what happens when the lights go out?
- Damage to critical equipment – how long to repair?
- The potential for fire?
- Negative impact to environment, community due to a mishap in your operations?
- Injury or death of personnel?
- Damaged customer loyalty and satisfaction due to late delivery?

If your electrical maintenance program alleviates any of the consequences listed above, then it has to be an asset, and as such the investment in setting up an EPM needs careful planning and implementation. This is where the information and guidelines contained within NFPA70E and 70B can help you to get it right.

NFPA 70B

NFPA 70B is a standard for implementing an effective Electrical Preventive Maintenance (EPM) program. "The purpose of an EPM program is to reduce hazard to life and property that can result from the failure or malfunction of electrical systems and equipment." NFPA 70B states that "a well-administered EPM program will reduce accidents, save lives, and minimize costly breakdowns and unplanned shutdowns of production equipment." "Without an EPM program, management assumes a greatly increased risk of a serious electrical failure and its consequences."

70B goes on to state that "dependability can be engineered and built into equipment, but effective maintenance is required to keep it dependable." "Electrical equipment deterioration is normal, but equipment failure is not inevitable. As soon as new equipment is installed, a process of normal deterioration begins. Unchecked, the deterioration process can cause malfunction or an electrical failure. An effective EPM program identifies and recognizes these factors and provides measures for coping with them."

70B outlines the following benefits of an EPM program:

- Asset protection: "Experience shows that equipment lasts longer and performs better when covered by an EPM program."
- Risk management: "An EPM program is a form of protection against accidents, lost production, and loss of profit."

  Energy conservation: "Equipment that is well maintained operates more efficiently and utilizes less energy."
- Increased uptime and profitability: through "reduced interruption of production" and "better workmanship and increased productivity"
- Improved employee morale and reduced absenteeism
- Possible reduction in insurance costs: due to the alternative "high cost of inadequate maintenance."

NFPA regards systematic and regular thermographic electrical inspections to be a critical part of an EPM program stating that "these (thermographic) inspections have uncovered a multitude of potentially dangerous situations. Proper diagnosis and remedial action of these situations have also helped to prevent numerous major losses… They can reduce typical visual examinations and tedious manual inspections and are especially effective in long-range detection situations." It goes on to endorse Thermographic electrical inspection as "relatively inexpensive to use considering the savings often realized by preventing equipment damage and business interruptions… (and is) considered a useful tool to evaluate previous repair work and proof test new electrical installations and new equipment still under warranty."

The 70B standard prescribes "routine infrared inspections of energized electrical systems should be performed annually prior to shutdown. More frequent infrared inspections, for example, quarterly or semiannually, should be performed where warranted by loss experience, installation of new electrical equipment, or changes in environmental, operational, or load conditions."

The standard is also very specific about performing "running inspections" (inspections made with equipment operating) and requires that "infrared surveys should be performed during periods of maximum possible loading but not less than 40 percent of rated load of the electrical equipment being inspected." In instances where IR Windows or viewing panes are not available, "equipment enclosures should be opened for a view of components whenever possible..." since it is not possible for infrared imagers to calculate internal temperatures through standard panel covers or standard materials used in visual inspection panes (i.e. tempered glass or Plexiglas) as these materials are non-transmissive in the infrared spectrum.

Of course, when thermographers and electricians open electrical panels to perform thermographic inspections per NFPA 70B guidelines and insurance requirements, they increase the risk of allowing one of these triggers to occur. NFPA 70E rates the removal of bolted panels on energized electrical equipment to be in the highest hazard/risk category. Consequently, NFPA 70E standards for electrical safety must be adhered to.

NFPA 70E

Originally chartered in 1976 and first released in 1979, the 70E standard is "intended for use by employers, employees, and OSHA." Its purpose was to assist OSHA in preparing a set of consensus standards to be used as a basis for evaluating electrical safety in the workplace. Through its eight revisions over roughly 30 years, the NFPA 70E Standard has made an indelible mark on safe work-practices throughout the US and throughout the world, although its greatest impact has only been recognized since the 2000 revisions which included clarification of personal protective equipment (PPE) requirements.

In part, the current 70E Standard requires employers to:

- Perform a Flash Hazard Analysis to define Arc Flash Boundaries and document the incident energy levels of related equipment or consult the 130.7(C)(9) tables
- Provide workers with appropriate levels of PPE
- Allow only qualified personnel to work on or near live parts
- Train workers on electrical safety and safe work-practices
- Use safety signs, symbols and accident prevention tags
- Provide tools for safe work

Hierarchy of Control

At the heart of NFPA 70E and OSHA initiatives is the hierarchy of control (as referenced in Annex F of the 2009 edition of 70E). Put simply, this concept attempts to control or mitigate risk wherever possible. In order of preference, the hierarchy of control seeks to mitigate risks by:

1. Risk Elimination
2. Substitution (with lower risk)
3. Engineering Controls (such as arc resistant switchgear)
4. Safe Work Practices
5. PPE

Image 1: Example of a Flash Suit

In short, the best way to reduce risk is to eliminate it. This is why NFPA 70E and OSHA state very plainly that electrical equipment should be de-energized prior to opening. Realizing that this is not

always possible for troubleshooting, inspecting or in situations where shutting down is not viable or poses a risk, there is an allowance made for PPE to be used as a *last resort* – similar to the least preferred method in the hierarchy of control.

The OSHA 1910.303 Linhardt Interpretation states clearly that "…with respect to arc-flash burn hazard prevention, the general provisions for the *Selection and use of work practices*... generally require de- energization of live parts before an employee works on or near them."

Although OSHA recommends that "employers consult consensus standards such as NFPA 70E," they fall short of fully endorsing the 130.7(C)(9) charts for PPE recommendations. Furthermore, they are on record in the Linhardt Interpretation as saying that some of the PPE protection and lack of lock-out/tag-out (LOTO) requirements do not offer workers as much protection as offered in Subpart S.

Keep in mind that OSHA's mandate to employers is to eliminate risk of work-place injury wherever possible and practical. To this end, PPE will always fall short of OSHA's goal of zero-tolerance. The 2009 edition of the 70E (130.7(A) FPM No.1) plainly states the limits of PPE:

"The PPE requirements of 130.7 are intended to protect a person from arc flash and shock hazards. While some situations could result in burns to the skin, even with the protection selected, burn injury should be reduced and survivable. Due to the explosive effect of some arc events, physical trauma injuries could occur. The PPE requirements of 130.7 do not address protection against physical trauma other than exposure to the thermal effects of an arc flash."

NFPA 70E 2012

The latest revision of 70E document took place in 2012. The following is a summary of some of the more significant changes.

New Definitions –

- The term "flame resistant (FR)" was replaced by the term "arc rated (AR)".
  This proposed change is meant to clarify that arc-rated clothing has been tested for exposure to electrical arcs, whereas not all FR materials have been.
- Incident Energy Analysis:
  A study used to predict the incident energy of an arc flash for a specified set of conditions.
- Working On:
  Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment a person is wearing.

Article 100

110.6(D)(1)(f) New
The employer shall determine, through regular supervision and through inspections conducted on at least an annual basis that each employee is complying with the safety related work practices required by this standard.

110.6(D)(3)(d) New
Retraining shall be performed at intervals not to exceed three years.

110.6(E)
The documentation shall contain the content of the training, each employee's name and dates of training.

110.7(E) Electrical Safety Program Procedures (ESP) Procedures
An electrical safety program shall identify the procedures for working within the limited approach boundary and for working within the arc flash boundary of energized electrical conductors and circuit parts operating at
50 volts or more or where an electrical hazard exists before work is started.

110.7(F) Hazard/Risk Evaluation Procedure
An electrical safety program shall identify a hazard/ risk evaluation procedure to be used before work is started within the Limited Approach Boundary and before work is started within the Arc Flash Boundary of energized electrical conductors and circuit parts operating at 50 volts or more or where an electrical hazard exists.

110.7(H) Electrical Safety Auditing - (1) Electrical Safety Program
The electrical safety program shall be audited to help ensure that the principles and procedures of the electrical safety program are still in compliance with the latest requirements and regulations.

The frequency of the audit shall not exceed three years.

110.9 Use of Equipment (prev. 130.4) - Test Instruments and Equipment
1. General: Only qualified persons shall perform testing work within the Limited Approach Boundary of energized electrical conductors or circuit parts operating at 50 volts or more.

Article 120

120.2(C)(2) - Form of Control
Two forms of hazardous electrical energy control shall be permitted: individual employee control, simple lockout/tagout, and complex lockout/tagout.

For the individual employee control and the simple lockout/tagout, the qualified person shall be in charge. For the complex lockout/tagout, the person in charge shall have overall responsibility.

Article 130

130.1(A)
Energized electrical conductors and circuit parts to which an employee might be exposed shall be put into an electrically safe work condition before an employee works within the Limited Approach Boundary of those conductors or parts. If any of the conditions in 130.1(A)(1) through 130.1(A)(3) exist:

(1) The employee is within the Limited Approach Boundary.
(2) The employee is within the Arc Flash Boundary.
(3) The employee interacts with equipment where conductors or circuit parts are not exposed, but an increased risk of arc flash hazard exists.

130.2(B) Shock Boundaries
Existing Table 130.2(C) becomes Table 130.2(C)(1), for AC systems
Table 130.2(C)(2) shall be used for the distances associated with various DC system voltages

130.3(C) Equipment Labeling
Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures and motor control centers that are likely to require examination, adjustment, servicing or maintenance while energized shall be field marked with a label containing all the following information:

(1) Only one of the following:
    a. Available incident energy
    b. Minimum arc rating of clothing
(2) Arc Flash Boundary
(3) Nominal system voltage
(4) Equipment identification
(5) Date of arc flash hazard analysis

130.6(G) New
(G) Doors, hinged panels, and the like shall be secured to prevent their swinging into an employee and causing the employee to contact exposed energized electrical conductors or circuit parts rated at 50 volts or more or where an electrical hazard exists if movement of the door, hinged panel, and the like is likely to create a hazard.

130.7(C)5 New - Hearing Protection
Employees shall wear hearing protection whenever working within the arc flash boundary.

Table 130.7(C)(9)(2) New
Renumber existing Table 130.7(C)(9) as Table 130.7(C)(9)(1) for AC Hazards and adds a new Table 130.7(C)(9)(2) for DC Hazards.

Annexes

Annex F
Revised Risk Assessment

Annex H
Revised Annex H to provide guidance on clothing selection. Annex H has been split into 4 sections:

- 2 sections which provide guidance on selecting personal protective clothing when using the Hazard/Risk Categories and:
- 2 sections providing guidance on selecting personal protective clothing when using incident energy values.

OSHA
The Occupational Health and Safety Administration (OSHA) enforce electrical safety regulations in the United States. Although OSHA has not adopted and does not mandate NFPA 70E compliance, you can be cited for non-compliance. If you wonder how this could be possible, remember that OSHA's authority to do so stems from the Occupational Safety and Health Act in particular Section 5(a)(1) and 29 CFR 1910.2(g).

Section 5(a)(1) "The General Duty Clause" of the Occupational Health and Safety Act, states that employers "shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees". This is the clause most cited by OSHA where unsafe work conditions are found to exist.

Section 29 CFR 1910.2(g) states a "National consensus standard" means any standard or modification thereof which has been adopted and promulgated by a nationally recognized standards-producing organization under procedures whereby it can be determined that persons interested and affected by the scope or provisions of the standard have reached substantial agreement on its adoption". NFPA 70E is considered a national consensus standard and as such, non-compliance leaves employers open for citation under this clause if they are found not to be in compliance.

SUMMARY
The implementation of the requirements outlined in the NFPA standards in industry give engineers a solid foundation to build a safe and effective electrical preventive maintenance program and as such improve their electrical safety records, the benefits of which will show reduced medical incident rates, workers compensation costs and other indirect costs resulting from electrical accidents.

An article in Insights Magazine by Joseph Weigel, states that Schneider Electrics North American Operating Division can attest first hand to the benefits of an effective EPM. Since 2003, the company has seen its medical incident rate drop by 72 percent in its North American facilities. That translates to a savings of approximately $10 million in workers' compensation savings for the 2010 calendar year.

Complying with the NFPA standards and practices allow companies to really show how much they value their workforce by maintaining a safe working environment, this has additional spin-offs in increased employee morale and reduced absenteeism, by providing the tools, training and maintenance programs to reduce the chances of injury in their workplace. That's a reputation for which any company would delight in.

REFERENCES

NFPA 70 - *National Electrical Code (NEC), 2011 Edition*
NFPA 70E - *Handbook for Electrical Safety in the Workplace, 2009 Edition*
NFPA 70B - *Recommended Practice for Electrical Equipment Maintenance, 2010 Edition*
IEEE 902-1998 – *Guide for Maintenance, Operation and Safety of Industrial and Commercial Power Systems* **ANSI/NETA MTS-2007** - *Standard for Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems*
ANSI Z10-2005 - *Occupational Health and Safety Management Systems*
ISO 14001: 2004 - *Environmental Management System*
OHSAS-18001-2007 - *Occupational Safety and Health Management Systems – Requirements*
ILO-OSH 2001 - *Guidelines on Occupational Safety and Health Management Systems*
CSA Z1000-2006 - *Occupational Safety and Health Management*
Insights Article-2010 – *Joseph Weigel – Avoid Devastating Electrical Arc Flash Accidents*

ABOUT THE AUTHOR

For over 30 years, Martin Robinson has been a pioneer in the field of maintenance technology. He spent 17 years in the British Army specializing in field maintenance of combat fleet vehicles. Mr. Robinson continues to be an innovator and pioneer the technological benefits of Infrared Thermography internationally. He has met with, consulted, or advised international maintenance and reliability leaders on electrical preventive maintenance (EPM) and electrical safety standards of NFPA and OSHA. A recognized authority in the field of Infrared Thermography (IR), Mr. Robinson has designed CBM programs to include IR, Non-destructive Testing (NDT) and implementation of green energy initiatives and energy management strategies. He is a Level III Certified Infrared Thermographer, Certified Maintenance and Reliability Professional (CMRP) through the Society for Maintenance and Reliability Professionals (SMRP), a member of IEEE, NFPA and is a standing member on the technical committee CSA Z463 guidelines on maintenance of electrical systems and IEEE P1814 - Electrical System Design to Improve Electrical Safety.

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