Systemic Safety

A quick guide to the NEC, NFPA, and OSHA electrical safety systems standards after the 2015 NFPA 70E rollout.

VIVID learning systems

A little background information

To reduce the risk of injury from hazards associated with electrical energy, including approach and arc flash hazards, Vivid's Arc Flash 2015 Edition on demand course meets the latest revision to the NFAP standard, and features a real life film showing workers wearing arc resistant clothing and other safety gear such as hard hats, but not performing the last step of the process - closing the doors when racking the breaker. The results of the failure to perform that task correctly ended with an explosion.

For a free lesson, visit learnatvivid.com/solutions/courses/nfpa-70e/arc-flash

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It is clear that businesses are reliant on electrical power and its continuous provision, yet the energy infrastructure and building systems that harness that power and make working safely possible, are often ignored or forgotten.

While true in many cases, that's a counterintuitive conclusion to reach; with the importance of energy required for productivity, and the improvement of smart grid technology and electrical safety devices, one would think that investments in electrical infrastructure are relatively common enhancements made by businesses in the modern age.

Nationwide, the problems posed by our aging electrical grid are well documented. That ongoing struggle—involving public and private utilities of all sizes—has mostly negative implications for major end consumers like businesses, from manufacturing and construction, to any commercial building owner.

If you're wondering what the cost interruption would be for your organization, the U.S. Department of Energy (DOE) created the Interruption Cost Estimate Calculator (ICE), a tool that any organization may use to estimate the cost of interruption and evaluate the benefits of improvements to system dependability.

Minimizing The Risk of Our Aging Electrical Grid

To minimize the risk involved with incidents where electrical power is interrupted, it is imperative that energy infrastructure and building systems receive equipment upgrades and preventative maintenance on a regular basis. Speaking generally, the more dependent an organization is on an uninterrupted supply of electrical power, the more concerned that organization should be with maintenance of the infrastructure that sustains it.

It's a question of operational expense; businesses hire qualified electricians to maintain operational infrastructure when business is good, or when expanding—not when times are lean. This is done with the expectation that these individuals will provide the service that is needed, while adhering to all standards, rules, installation procedures, and employee safety requirements. That's a fair expectation for any heavily regulated employment sector.

It is important to recognize the risk potential for businesses posed by neglect of electrical infrastructure, and when corrective electrical work is performed. From the NEC to the NFPA, there are specific safety protocols that must be adhered to. Let's talk about why those standards matter.

The U.S. Department of Energy created the Interruption Cost Estimate Calculator, a public tool used to estimate the cost of interruption and evaluate the benefits of improvements to systems dependability. icecalculator.com

Arc flash can result in severe burns, injury from contact with flying objects, hearing loss, and more.

Voltage, Faults, and Arc Flash

Voltage is the stabilizing force of electricity and current, the fluctuating energy needed to make things work. When power is obtained from the grid—through a transformer and then to building equipment—the necessary voltage for operation is secured, and this level of voltage remains relatively consistent. The current that is needed to operate facilities is then determined, along with a set value for normal operation.

In terms of risk, the primary issue is in how much additional current may reach a facility during an adverse incident, before the circuit opens and disconnects the source of electricity for us. Those incidents are known as electrical faults. Here's the danger: fault currents may produce a deadly event called an arc flash.

When a fault occurs, protective devices deployed by the utility provider either function as expected, by interrupting the power to operate, or modern building equipment will intervene in a similar manner—unless such equipment has been neglected. The longer it takes equipment to open and remove a fault, the greater the current allowed to reach a facility.

By using equipment that will operate quickly in the event of a fault incident, building operators can greatly reduce or eliminate the potential damage to facilities and employees resulting from faults. This protective equipment, commonly referred to as "overcurrent protection devices", must be properly engineered and installed to avoid false operation.

This is where a series of electrical safety standards become relevant.

Electrical Safety Standards

In the past, requirements for overcurrent protection were not emphasized in the National Electrical Code (NEC) standards or recognized through OSHA regulation. Now, however, codes and standards have been revised to reflect the necessity of overcurrent protection devices and preventative electrical maintenance.

There are national standards related to electrical equipment, safety, employee protective wear, and procedure; these standards are enforceable by OSHA, and therefore applicable to all employers.

Electrical workers and contractors must follow these guidelines for safe installation and maintenance work, or expose operations to risk and liability:

- National Electrical Code (NEC)
- OSHA 29CFR1910 (General Industry)
- OSHA 29CFR1926 (Construction)
- NFPA 70E- Electrical Safe Work Practices

We'll examine each group of standards and the association with overcurrent protection and arc flash, beginning with the NEC.

National Electrical Code (NEC)

Articles 110.9 and 110.10 of the NEC code provide for interrupting ratings, circuit impedance, short-circuit ratings, and other standards associated with electrical safety systems.

For employee protection (Arc-Flash Hazard Warning), article 110.16 states: "...electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers, and which 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 markings shall be located so as to be clearly visible to qualified persons before examination adjustment, servicing, or maintenance of the equipment."

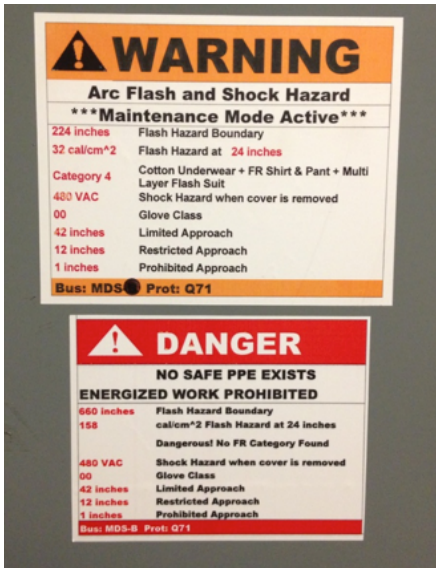
ARTICLES 110.21—MARKING

(A) Manufacturer's Markings

The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified shall be placed on all electrical equipment. Other markings that indicate voltage, current, wattage, or other ratings shall be provided as specified elsewhere in the Code. The marking or label shall be of sufficient durability to withstand the environment involved.

(B) Field-Applied Hazard Markings

Where caution, warning, or danger signs or labels are required by the Code, the labels shall meet the following requirements:



1. The marking shall adequately warn of the hazard using effective words and/or colors and/or symbols.
2. The label shall be permanently affixed to the equipment or wiring method and shall not be hand written.
3. The label shall be of sufficient durability to withstand the environment involved.

Exception to (2): Portions of labels or markings that are variable, or that could be subject to changes, shall be permitted to be hand written and shall be legible.

ARTICLE 110.24—AVAILABLE FAULT CURRENT

(A) Field Marking

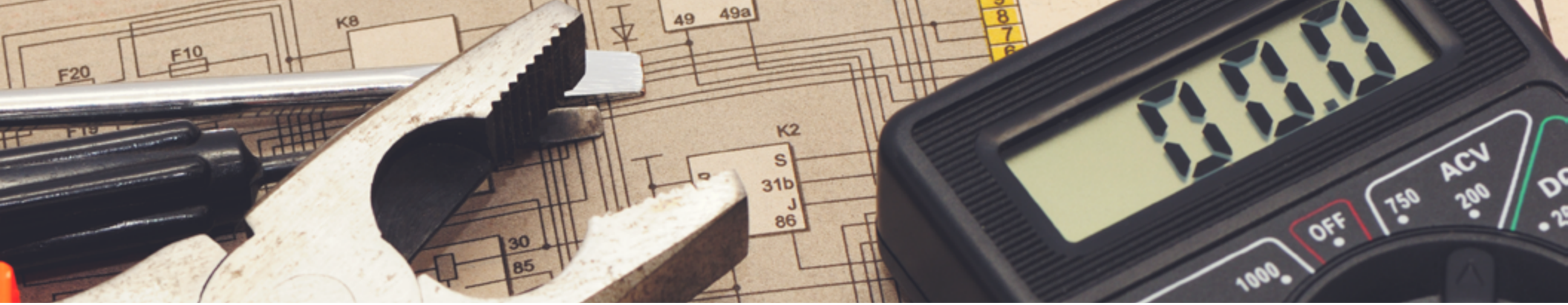
Service equipment in the other than dwelling units shall be legibly marked in the field with the maximum available fault-current. The field marking(s) shall include the date the fault-current calculation was performed and be of sufficient durability to withstand the environment involved.

Informational Note: The available fault-current marking(s) addressed in 110.24 is related to required short-circuit current ratings of equipment. NFPA 70E-2012, Standard for the Electrical Safety in the Workplace, provides assistance in determining the severity of potential exposure, planning safe work practices, and selecting personal protective equipment.

(B) Modifications.

When modifications to the electrical installation occur that affect the maximum available fault current at the service, the maximum available fault current shall be verified or recalculated as necessary to ensure the service equipment ratings are sufficient for the maximum available fault current at the line terminals of the equipment. The required field marking(s) in 110.24(A) shall be adjusted to reflect the new level of maximum available fault current.

Exception: The field marking requirements in 110.24(A) and 110.24 (B) shall not be required in industrial installations where conditions of maintenance and supervision ensure that only qualified persons service the equipment.



OSHA's Electrical Standards

The base, governing standard for compliance is OSHA 29 CFR 1910.333(a): "...employers must employ safety-related work practices to prevent electrical shock or other injuries resulting from either direct or indirect electrical contact." Under that directive, OSHA has a series of standards concerning the protection of workers which relate to electrical safety systems.

These laws are broadly applicable, for any organization under the agency's large jurisdictional umbrella; state OSHA plans may have different rules, or may have adopted these same electrical safety standards outright. If your business is regulated by a state-sponsored occupational safety agency, then check those standards accordingly.

1910.303—INTERRUPTING RATING

Equipment intended to interrupt current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment. Equipment intended to interrupt current at other than fault levels shall have an interrupting rating at nominal circuit voltage sufficient for the current that must be interrupted.

1910.303—CIRCUIT IMPEDANCE AND OTHER CHARACTERISTICS

The overcurrent protective devices, the total impedance, the component short-circuit current ratings, and other characteristics of the circuit to be protected shall be selected and coordinated to permit the circuit protective devices used to clear a fault to do so without the occurrence of extensive damage to the electrical components of the circuit. This fault shall be assumed to be either between two or more of the circuit conductors, or between any circuit conductor and the grounding conductor or enclosing metal raceway.

OSHA's Electrical Standards

1910.303—HAZARD MARKING REQUIREMENTS

Other markings giving voltage, current, wattage, or other ratings as necessary.

1910.304—OVERCURRENT PROTECTION

Conductors and equipment shall be protected from overcurrent in accordance with their ability to safely conduct current. The following requirements apply to overcurrent protection of circuits rated 600 volts, nominal, or less.

1910.304—OVERCURRENT DEVICES

Except for motors running overload protection, overcurrent devices may not interrupt the continuity of the grounded conductor unless all conductors of the circuit are opened simultaneously.

1910.304—LIMITING CURRENT & DISCONNECTING MEANS

A disconnecting means shall be provided on the supply side of all fuses in circuits over 150 volts to ground and cartridge fuses in circuits of any voltage where accessible to other than qualified persons so that each individual circuit containing fuses can be independently disconnected from the source of power. However, a current-limiting device without a disconnecting means is permitted on the supply side of the service disconnecting means. In addition, a single disconnecting means is permitted on the supply side of more than one set of fuses as permitted by the exception in § 1910.305(j)(4)(vi) for group operation of motors, and a single disconnecting means is permitted for fixed electric space-heating equipment.

1910.304—AVAILABILITY OF OVERCURRENT DEVICES

Overcurrent devices shall be readily accessible to each employee or authorized building management personnel. These overcurrent devices may not be located where they will be exposed to physical damage or in the vicinity of easily ignitable material.

1910.304—FUSE & BREAKER SAFETY

Fuses and circuit breakers shall be so located or shielded that employees will not be burned or otherwise injured by their operation. Handles or levers of circuit breakers, and similar parts that may move suddenly in such a way that persons in the vicinity are likely to be injured by being struck by them, shall be guarded or isolated.

1910.304—OVERCURRENT RELAY

Circuit breakers used for overcurrent protection of three-phase circuits shall have a minimum of three overcurrent relays operated from three current transformers. On three-phase, three-wire circuits, an overcurrent relay in the residual circuit of the current transformers may replace one of the phase relays. An overcurrent relay, operated from a current transformer that links all phases of a three-phase, three-wire circuit, may replace the residual relay and one other phase-conductor current transformer. Where the neutral is not grounded on the load side of the circuit, the current transformer may link all three phase conductors and the grounded circuit conductor (neutral).

1910.304—UNGROUNDED CONDUCTORS

If fuses are used for overcurrent protection, a fuse shall be connected in series with each ungrounded conductor.

1910.304—CURRENT DETECTION VALUE

Each protective device shall be capable of detecting and interrupting all values of current that can occur at its location in excess of its trip setting or melting point.

1910.304—COORDINATION OF PROTECTIVE DEVICES

The operating time of the protective device, the available short-circuit current, and the conductor used shall be coordinated to prevent damaging or dangerous temperatures in conductors or conductor insulation under short-circuit conditions.

1910.304—FUSES & AMPACITY

The continuous ampere rating of a fuse may not exceed three times the ampacity of the conductors. The long-time

trip element setting of a breaker or the minimum trip setting of an electronically actuated fuse may not exceed six times the ampacity of the conductor. For fire pumps, conductors may be protected for short circuit only.

GENERAL DUTIES CLAUSE

OSHA's mission is to secure safe working conditions for the American workforce. To accomplish that, OSHA may invoke the agency's 'General Duties Clause', when its own rules and standards fail to sufficiently address certain hazardous working conditions. The General Duties Clause is a catch-all enforcement tool, written to provide OSHA flexibility to mitigate hazards it has yet to recognize.

OSHA's General Duties Clause:

a. Each employer

1. 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;
2. shall comply with occupational safety and health standards promulgated under this Act.

If electrical work is knowingly or unknowingly performed without regard for NEC, NFPA 70E, or OSHA guidelines, then the agency can cite an organization by invoking the General Duties Clause. That's why it matters.

Medical care for an arc flash victim often exceeds $1 million.

Important Changes to NFPA 70E – Electrical Safe Work Practices Standard

Often referred to as the 'how to' standard, the NFPA 70E is a critical interpretive link between the National Electrical Code (NEC) and OSHA standards, addressing safety and compliance. NFPA 70E is where electrical contractors turn when they need information about how to comply with OSHA standards. The NFPA 70E is updated on a three year cycle to reflect changes in technology that employers and electrical workers need to be aware of.

For 2015, the National Fire Protection Association (NFPA) has brought forward a critical revision to its standard for electrical safety in the workplace (70E). Changes for the 2015 edition are notable for the emphasis on risk assessment and hazard awareness.

How?

Aside from changing several important definitions to include the phrase "risk assessment", the scope of the rule was amended to clarify that "training" and "auditing" are equally important practices for working safely. Additionally, new sections were added to require risk assessments of battery systems, and when cutting or drilling into equipment, floors, walls, or other structural elements, where a likelihood of contact is presented.

Remember that the new standard is now applicable. That's one reason why training your electrical workforce for compliance with the updated NFPA 70E standard is important. Of course, the most important reason to begin training on the revised standard is to equip your workforce with the current best practices for safe electrical work.

Important Changes to NFPA 70E - Electrical Safe Work Practices Standard

Here's a summary of the major changes...

EVALUATING RISK

- Change "arc flash analysis" to "arc flash risk assessment"
- Change "shock hazard analysis" to "shock risk assessment"
- Change "electrical hazard analysis" to "electrical hazard risk assessment"
- Change "hazard identification and risk assessment" to "risk assessment"

TRAINING & AUDITING

Safety related maintenance requirements and other administrative controls were added to the Scope statement to clarify that training and auditing are equally important safety-related work practices.

CHANGES TO DEFINITIONS

- Removal of "bare-hand" work since the term is considered to be "utility" work
- "Energized Electrical Work Permit" added to definitions
- "Qualified person" was revised to correlate the definition with OSHA 1910.399
- Deleted "Prohibited Approach Boundary"

CHANGES FOR ELECTRICAL SAFETY PROGRAMS

- Electrical Safety Program must now include condition of maintenance
- Auditing of field work must now be performed annually
- Requires location, sizing and application of temporary grounding in job planning

OPERATION OF ELECTRICAL EQUIPMENT

Clarifying where normal operation of electric equipment is permitted:

- Properly installed and maintained;
- Doors closed and secured;
- All covers in place and secure;
- No evidence of impending failure.

ARC FLASH PPE & FIELD MARKING

- Either Incident Energy Analysis (IEA) method or arc flash PPE categories method to be used—not both.
- Incident Energy Analysis method cannot use PPE table 130.7(C)16
- Field marking label is the responsibility of the equipment owner.
- Equipment owners or representatives are responsible for maintenance of electrical equipment & documentation.

NEW TASK & EQUIPMENT TABLES FOR PPE

- New task based table (AC&DC) determines when arc flash PPE is required—130.7(C)(15)(A)(a)
- New equipment tables to determine PPE category—(130.7(C)(15)(a)(b);130.7(C)(15)(B)
- HRC 0 removed.

BOUNDARY CHANGES

- Changed "insulated tools" or "handling equipment" from "limited" to "restricted boundary."
- Conductive articles shall not be worn within the restricted approach boundary.
- Barriers cannot be placed closer than the limited approach or arc flash boundary (whichever is closer).

NEW SECTIONS & REQUIREMENTS

- New section added requiring the employer to perform a risk assessment before cutting or drilling into equipment, floors, walls or structural elements where there is likelihood of contact.
- New maintenance requirements for test equipment; must now include functional verification 110.4(A)(5); 250.4
- New section 320.3(A)(1) requires risk assessment on battery systems.

Conclusion

People, training, and preparation. Safety and human resources professionals know that employers should never overlook those three things. Understanding and complying with NEC, NFPA 70E, and OSHA guidelines will address all three of the business critical assets in relation to electrical worker safety. Any loss due to an electrical incident can affect a business through loss of property and employees (contractors) or both.

The performance of a risk analysis can help with application of proper protection and safe work procedures for maintenance of electrical infrastructure.

The process to follow after identifying hazards is as follows:

- Elimination
- Substitution
- Engineering Controls
- Awareness
- Administrative Controls
- Personal Protective Equipment

Proper overcurrent protection does not totally eliminate hazards, but it significantly reduces the damage potential to property and people, and should be the first choice in protecting both the workforce and property for your organization.

An example of the use of current limiting devices for facilities is shown below, including the proper labels on equipment, warning signs and signals. Please note the reduction of heat (calories per centimeter squared) when placing the equipment in maintenance mode. This significantly lowers the incident energy to a more manageable level.

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