AABC Commissioning Group

AIA Provider Number 50111116

# A NFPA 70B & 70E Overview: Eliminate the Risk of Electrical Hazards & Avoid Expensive Shutdowns

Course Number: CXENERGY1820

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# Course Description

Facility shutdowns due to electrical equipment failures and catastrophic accidents that result due to improper maintenance, cost organizations millions of dollars inventory and injury related claims. This session focuses on the importance of electrical safety and maintenance programs, OSHA requirements and definitions for CFRs 1910.147 & 303 and 305 and guidance of NFPA 70E and 70B standards on electrical safety and recommended practice for electrical equipment maintenance. Topics of discussion include, Risk Control Hierarchy, methods to eliminate risk or mitigate risk using safety-by-design controls, technologies and trends in predictive maintenance tools and using remote monitoring tools.

# Learning Objectives

At the end of the this course, participants will be able to:

1. Learn why predictive maintenance is critical for electrical safety and reliability.

2. Learn about common electrical equipment failures and catastrophic accidents and learn about OSHA, NFPA 70E & 70 B standards reference in maintenance programs.

3. Learn about things to consider in developing an effective maintenance programs and significance of temperature rise in electrical equipment.

4. Review current technologies and future trends in PdM tools.

# Predictive vs Routine Maintenance

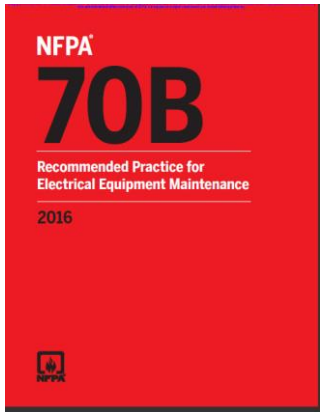
- Risk priority is the primary driver
- Predictive Maintenance can often be the lower-cost option
- Predictive Maintenance sometimes results in longer intervals between maintenance

# Key Drivers for Electrical Preventive Maintenance

- Regulatory
- Safety
- Cost Management
- Service Continuity

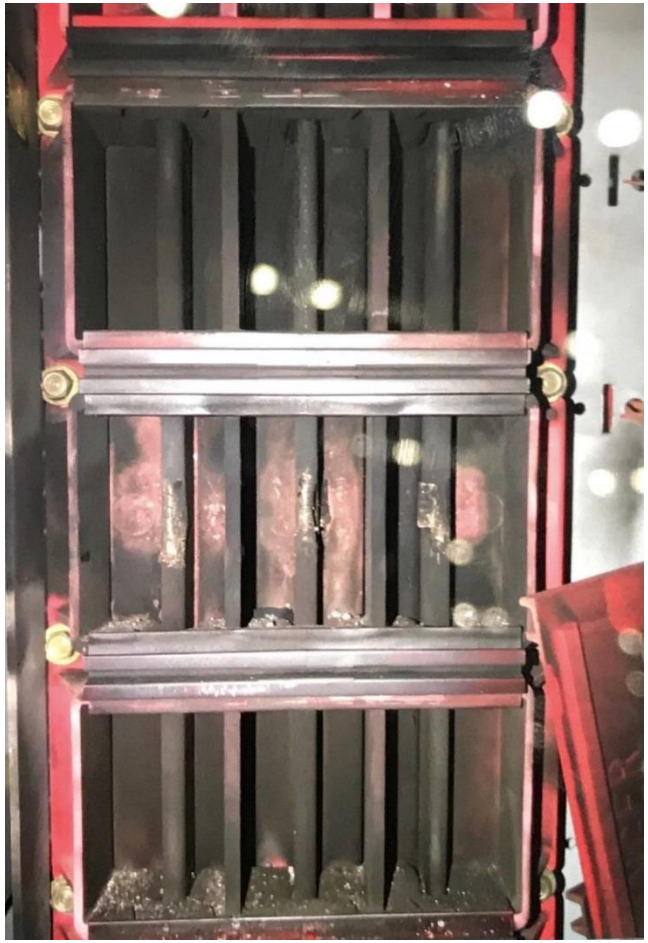
# OSHA & NFPA

- 29 CFR 1926.431 NFPA 70B
- 29 CFR 1910.331-.335, NFPA 70E
- OSHA training requirements have maintenance component
- OSHA defers to manufacturers required maintenance schedules

# Arc Flash Incidents

5000A busway feeder, 10Ft, 750 lbs.
over 2000 ft. installed



MCC Bucket

# Loose Connections & Temperature Rise

- Load Conditions
- Duty Cycles
- Mechanical wear and stress
- Incorrect crimping of  connections
- Improper cable training
- Thermal expansion & contractions
- Vibrations and Harmonics

# Downtime Costs by Industry Sector

- Average  Revenue Loss:
  - **~$1.0 Million/Hour**
- Predictive Maintenance can often be the lower-cost option
- Predictive Maintenance often results in longer intervals between maintenance

**Potential Downtime Costs per Industry Sector**

| Industry Sector | Revenue Loss/Hour |
|---|---|
| Energy | $2,817,846 |
| Telecommunication | $2,066,245 |
| Manufacturing | $1,610,654 |
| Financial Institution | $1,495,134 |
| Information Technology | $1,344,461 |
| Insurance | $1,212,444 |
| Retail | $1,107,274 |
| Pharmaceuticals | $1,082,252 |
| Banking | $996,802 |
| Food & Beverage | $804,192 |
| Consumer Products | $785,719 |
| Chemicals | $704,101 |
| Transportation | $668,586 |
| Utilities | $643,250 |
| Healthcare | $636,030 |
| Metals/Natural Resources | $580,588 |
| Professional Service | $532,510 |
| Electronics | $477,366 |
| Construction and Engineering | $389,601 |
| Media | $340,432 |
| Hospitality | $330,654 |
| | |
| Average | $1,010,536 |

Source: META Group, Stamford, CT[13]

# NFPA 70B Code Reference

## Loose Connections & Temperature Rise:

- Section 17.9: Loose Connections. Loose connections are the most common cause of excessive heat. Periodic maintenance checks should involve checking for loose connections or evidence of overheating…"
- Section 15.2.15.1: "Temperatures over design levels for prolonged periods can reduce the electrical life of organic insulating materials…"
- Section 15.2.15.2: Localized heating (hot spots) can sometimes occur and can be masked because the overall temperature of the surroundings…"
- Section 11.17.5.6: "Section 9 and table 10.18 of the ANSI/NETA/MTS, Standard for Maintenance Testing Specifications for Electrical power distribution equipment and systems suggests temperature benchmark…."
  - Temperature differences of 1° C to 3°C indicate possible deficiency and warrant investigation
  - Temperature differences of 4° C to 15°C indicate deficiency; repairs should be made as time permits
  - Temperature differences of 16°C and above indicate major deficiency; repairs should be made immediately."

# NFPA 70B: “Personnel Safety”

Personnel safety is **very important** when performing maintenance

- 7.1.3.1 Some of the considerations in Article110 of *NFPA 70E*:
  - (1) Training requirements *(see 110.2)*
  - (2) Electrical safety program *(see 110.1)*
  - (3) Use of electrical equipment *(see 110.4)*
- 7.1.3.2 Some Considerations in Article 120 of *NFPA 70E*:
  - (1) Process for establishing and verifying an electrically safe work condition *(see 120.5)*
  - (2) De-energized electrical equipment that has lockout/ tagout devices applied*(see 120.4.(B)(1)*
  - (3) Temporary protective grounding equipment *(see 120.3)*

# NFPA 70E: “Properly Installed and Maintained”

**Article 130.2 (A) Normal Operation.** Normal operation of electric equipment shall be permitted where all of the following conditions are satisfied:

1) The equipment is properly installed.

2) The equipment is properly maintained.

3) The equipment doors are closed and secured.

4) All equipment covers are in place and secured.

5) There is no evidence of impending failure.

# New additions in 2018 edition:

**Article 130.2. (A)(4).(3) The equipment is used in accordance with instructions Included in the listing and labeling and in accordance with manufacturer's instructions.**

**Article 130.1 Energized Work Permits**

- **Additional Hazards or Increased Risk.** Energized work shall be permitted where the employer can demonstrate that de-energizing introduces additional hazards or increased risk.
- **Infeasibility.** Energized work shall be permitted where the employer can demonstrate that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations.

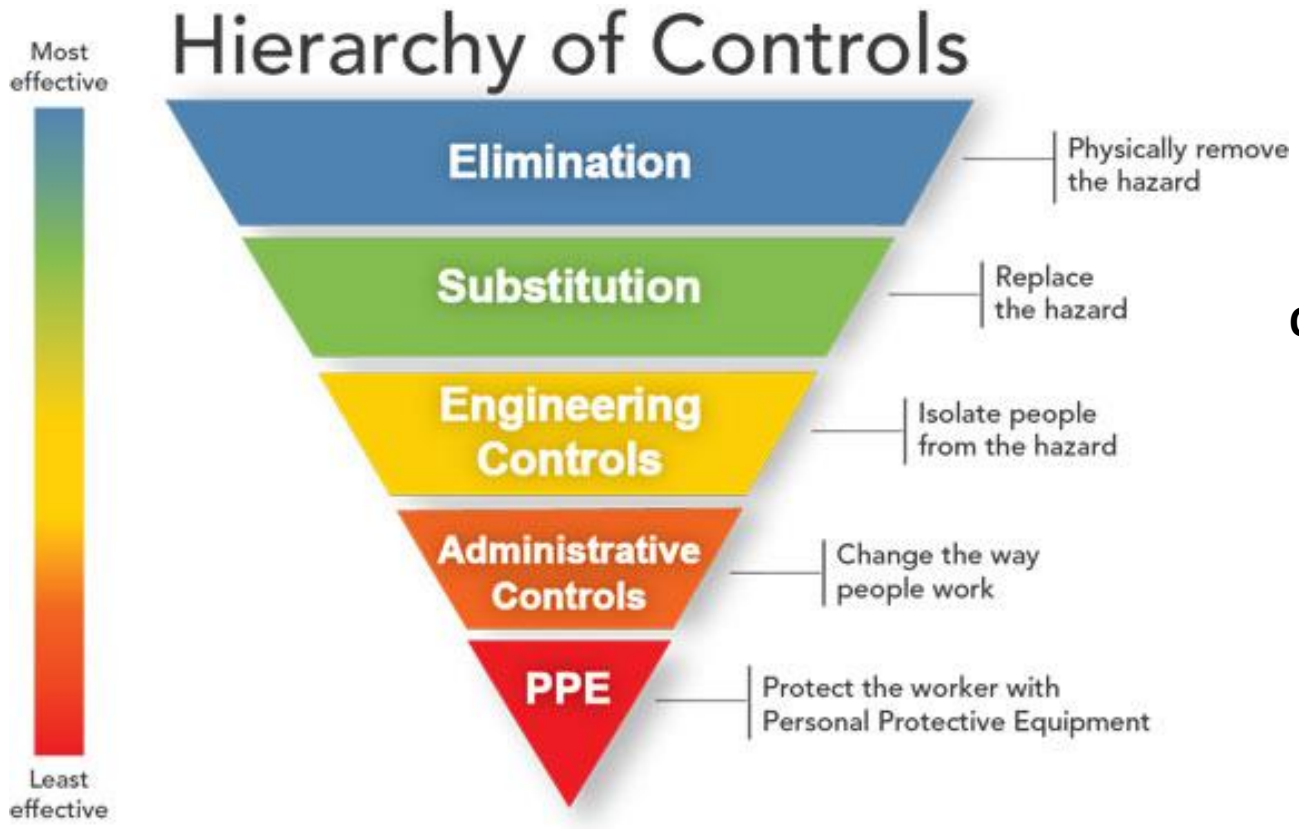
**Article 110.1(B) Inspection**

1. The electrical safety program shall include elements to verify that newly installed or modified electrical equipment or systems have been inspected to comply with applicable installation codes and standards prior to being placed into service.

# NFPA 70E Requires…

- Employer provide safety-related work practices and train the employee
- Employee implement safety-related work practices
- Employer documents each employee has received training
- Employer document employee proficiency and maintain the records for duration of employment – including employees name, training content and training dates
- Employer responsibility to provide appropriate PPE and ensure employees follow all policies related to energized vs. de-energized work

# Risk Control Hierarchy




**Our Goal must be:**

1. **Elimination**
2. **Engineering Controls**

**PPE must be your last line of defense**

# NFPA 70B Code Reference

## Thermography Programs:

- **Section: 11.17.1.1:** "Infrared inspections **should be performed by qualified and trained personnel** who have an understanding of infrared technology, electrical equipment maintenance…"
- **Section 11.17.3.1:** "Infrared inspections **require special measures and analysis**. Equipment enclosed for safety or reliability can be difficult to scan or to detect radiation from within. Special precautions, including the removal of access panels, might be necessary for satisfactory measurements…"
- **Section 11.17.5:** *Inspection frequency and procedures* ***"Routine infrared inspections of energized electrical systems should be performed annually prior to shut down.*** *More frequent infrared inspections, for example, quarterly or semi-annually, should be performed where warranted by loss experience, installation of new electrical equipment, or changes in environmental, operational or load conditions."*
- **Section 11.17.5:** Inspection frequency and procedures "Routine infrared inspections of energized electrical systems **should be performed annually prior to shut down.** More frequent infrared inspections, for example, quarterly or semi-annually…"

# NFPA 70B Code Reference

## Sensing, Indicating & Control Systems in Maintenance of Electrical Equipment Subject to Long Intervals Between shutdowns:

- Applies to both low and medium voltage systems
- Sensing, Indicating and Control Systems

- **Section 12.4.5.1:** The need for and frequency of inspection and maintenance are determined by the effect on safety, plant operations, and the severity of service. Also, some components can be readily isolated, while others can be inspected only during plant or process shutdowns.
- **Section 12.4.5.2:** Visual inspection either by plant operators during normal operations or as part of a scheduled inspection can assist in detection of deficiencies such as loose connections, overheating, and excessive vibration.
- **Section 12.4.5.3:** Sensing, indicating, and control devices can be divided into two categories: primary elements and secondary elements.

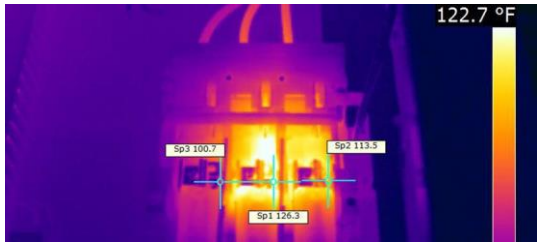
  (1) Primary elements are elements in contact with the process medium directly or indirectly and that might or might not be isolated from the process medium.

  (2) Secondary elements are transmitting, recording, or controlling devices. Some are normally in use and thus receive an automatic day-to-day check. Some are remotely located or infrequently used and require a check at regular intervals.

**Reliability Centered Maintenance (RCM) is identified in Section 15.2.3.2 of 70B-2016 and called out in detail in Chapter 30 and informational Annex N.**

# Thermography and It's Challenges

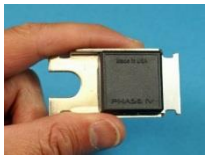
- Thermography Programs
- Open-door Thermography
  - Annually/ Semi-annually
- Closed-door Thermography
  - IR windows
  - More frequent (Monthly)





# Trends in Temperature Monitoring

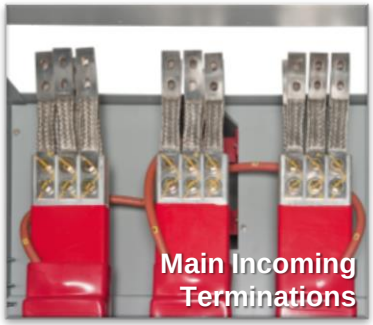
- Thermography Programs
- Open-door Thermography
  - Annually/ Semi-annually
- Closed-do Continuous monitoring
- Modifications to install brackets
- Sometimes requires batteries
- Can’t see all locations with limited view
- Very expensive for all points

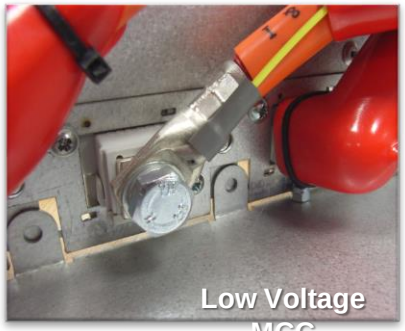


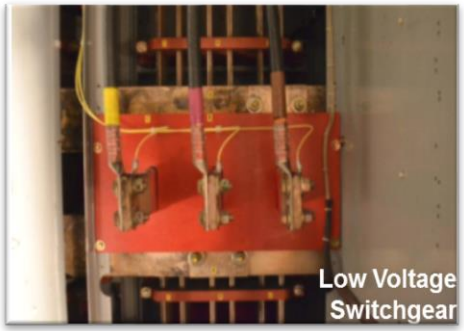

# Critical Connections to Monitor

| TYPE OF EQUIPMENT | POTENTIAL FAILURE POINTS (PFPs) |
|---|---|
| **MV Switchgear** | **a. Line/Load Breaker Stabs** |
| | **b. Main Bus Compartment** |
| | **c. Field Terminations** |
| | **d. Shipping Splits** |
| **MV MCC** | **a. Field Terminations** |
| | **b. Contractor Fuse Barrels** |
| **LV Switchgear** | **a. Line/Load Breaker Stabs** |
| | **b. Field Terminations** |
| | **c. Shipping Splits** |
| **LV MCC** | **a. Field Terminations** |
| | **b. Busbar Splits** |
| **Load Break & Transfer Switches** | **a. Line/Load Connections** |
| | **b. Tie-Connections** |
| **Bus Ducts** | **a. Connections at Bends** |
| | **b. Critical Connections at Splits** |
| **Large Batteries/Inverter Systems** | **a. Battery Post Terminals** |
| | **b. Interconnect Links** |
| **Large Generators/Motors** | **a. Terminations** |

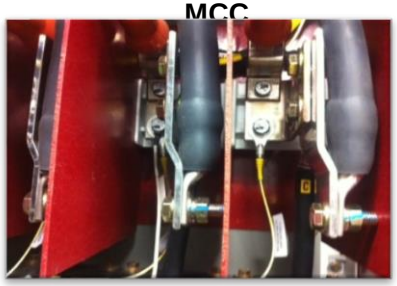
# Application Ideas

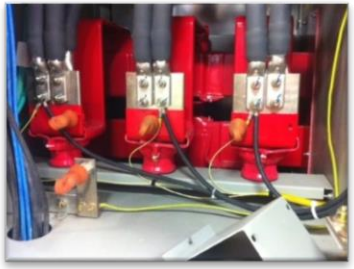



MV
MCC





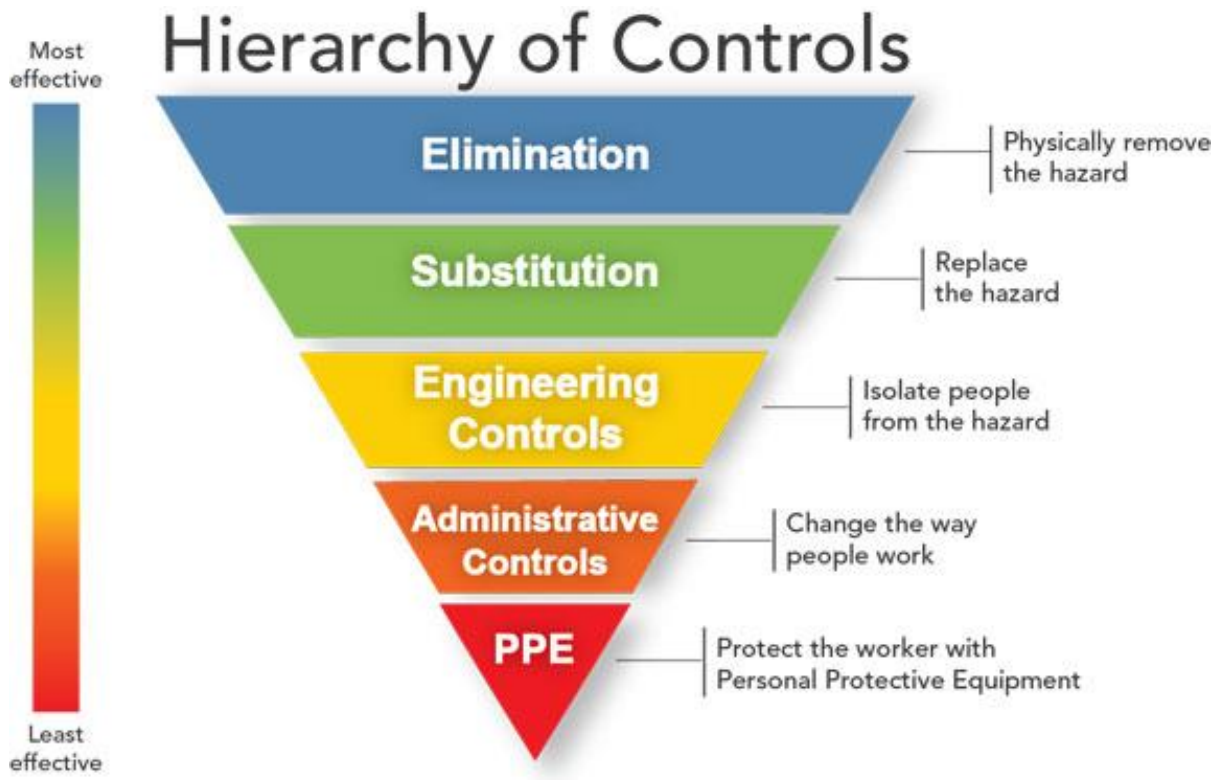
# Other Application Ideas

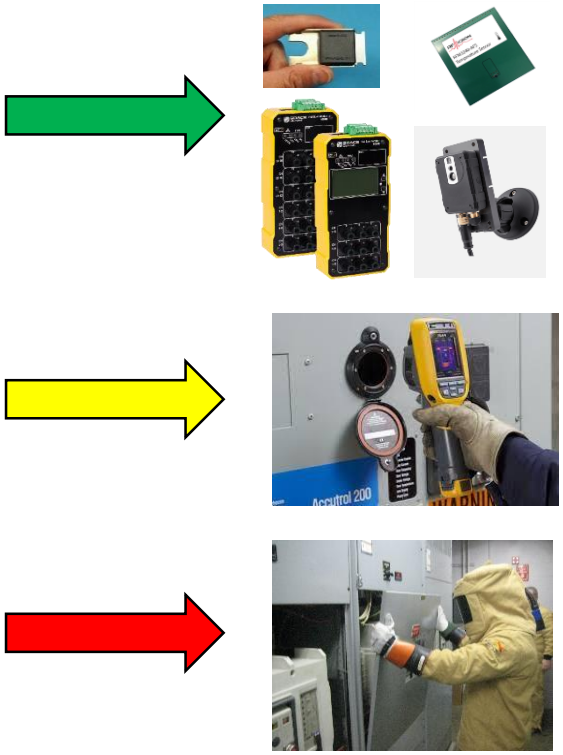


# Comparison of Open Door / IR Windows / Continuous Monitoring

| Description | Open door Thermography | IR Windows | Hot Spot Monitor |
|---|---|---|---|
| Exposure to incident energy | High | Medium | None |
| Personal Protective Equipment (PPE) | Required | Required | None |
| Device Calibration | Required | Required | Not required |
| Trending capabilities | No | No | Yes |
| Access to critical connections / complex system geometry | No | No | Yes |
| Alarm capability | No | No | Yes |
| Integration with existing SCADA/ DCS systems | No | No | Yes |
| Ambient measurement | No | No | Yes |
| Structural Degradation | N/A | Yes | No |
| Inspection frequency | Semi/Annual | Quarterly | Continuous |
| Technology | Non- contact | Non- contact | Non-conductive contact |

# Summary


Most effective
Hierarchy of Controls
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment
Least effective



This concludes The American Institute of Architects
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