How to Build a Safe and Effective Electrical Maintenance Program
The Business Case

Ask Yourself the Following Questions:

• What is your dependence on electrical energy and control systems?

• What are the consequences of an unplanned mishap in your electrical systems?

• How can you improve your electrical systems reliability?
Electrical Systems Are Critical

Any error or disruption to your electrical systems **WILL** have a **HUGE** cost to your business!
Creating an Electrical Assets Maintenance Strategy Using Reliability Centered Maintenance Processes
Maintenance Ensures Safe – Reliable Assets

What is a complete maintenance strategy?

• Preventive Maintenance (PM)
• Predictive Maintenance (PdM)
• Failure Finding Tasks (Hidden Failures)
• Consequence Reduction Tasks (RTF)

Source: Doug Plucknette, GPAlied
Maintaining Electrical Assets

• How do we determine the maintenance that needs to be performed to ensure electrical assets are safe and reliable?

• Start with NFPA standards 70B and 70E
NFPA 70B

• Committee established 1968
  – To address “preventative maintenance of electrical systems and equipment used in industrial-type applications with the view of reducing loss of life and property.”

• 2006 Edition
  – Enhanced Focus on Safety
  – Importance of Baseline Performance Data
  – How to Apply RCM (Reliability Centered Maintenance)
NFPA 70B, cont’d

• 2010 Edition (Approval Date: Dec 5th 2009)
  – Reorganization of documentation, including grouping of related topics plus consolidation of testing information
  – New material on emergency preparedness and electrical system and equipment restoration
  – New recommendations on how to conduct outsourcing of electrical equipment maintenance
  – New information on failure modes effects and criticality analysis (FMECA)
NFPA 70B 2010

• The *2010 NFPA 70B* is a guide for creating and administering an effective Electrical Preventive Maintenance program (EPM)

• Preventive maintenance is the key to:
  – Reducing accidents
  – Saving lives
  – Avoiding costly breakdowns
  – Work stoppages
NFPA 70B 2010, cont’d

• 70B outlines the following benefits of an Electrical Preventive Maintenance (EPM) program:
  – Asset Protection
  – Risk Management
  – Energy Conservation
  – Increased uptime and profitability
  – Improved employee morale and reduced absenteeism
  – Possible reduction in insurance costs
NFPA 70B 2010, cont’d

• 70B Does not address:
  – The context in which you operate the equipment
  – The present condition of your assets
  – The experience/capabilities of your people
  – Maintenance best practices in terms of PdM (Thermography, MCE, Ultrasound)
  – The failure modes responsible for electrical failures

Source: Doug Plucknette, GPAlied
Developing a Complete Maintenance Strategy

• Recognizing that while we may have many common electrical components the environment and context in which we operate may be very different

• Consider the following; what environmental conditions are your electrical assets exposed to?

Source: Doug Plucknette, GPAlied
What Environmental Conditions Are Your Electrical Assets Exposed To?

- Hot/Cold
- Snow/Rain
- Dirt/Dust
- Chemicals
- Explosive/Flammable
- Neat/Cluttered

Source: Doug Plucknette, GPAllied
How Might The Operating Context Of Your Equipment Differ From Others?

• Long continuous runs or start and stop?
• Single speed or VFD?
• Push button or PLC control?
• Lots of instruments, feedback, controls, alarms or little to none?

Source: Doug Plucknette, GPAllied
What Are The Capabilities And Experience Of Your Maintenance Crew?

• “I helped my friend wire a house once!”
• Received training and experience on the job!!
• Some have formal training
• Company has a formal apprentice program

Source: Doug Plucknette, GPAllied
The Only Way to Build a Complete Maintenance Strategy...

• Reliability Centered Maintenance
  – RCM takes into consideration:
    • The environment in which we operate
    • The context in which we operate
    • The experience or inexperience of our people
    • The performance standards that must be maintained to ensure safe reliable assets

Source: Doug Plucknette, GPAllied
Reliability Centered Maintenance (RCM)

Chapter 30.1.1 of NFPA 70B States:

“RCM is the process of developing preventative maintenance (PM) programs for electrical and mechanical systems used in facilities based on the reliability characteristics of those systems and economic considerations, while ensuring that safety is not compromised”

Source: NFPA 70B, 2010
Reliability Centered Maintenance (RCM)

Annex N1 – N5 of NFPA 70B outlines:

“This annex is included for informational purposes only and includes information relating to definitions and terminology used in RCM and detailed tables relating to equipment reliability, inherent availability and operational availability”
The 7 steps of Reliability Centered Maintenance

1) Functions – Clearly describe Main and Support Functions as well as performance standards we need to maintain.

2) Functional Failures – Describe the inability to maintain specified performance standards.

3) Failure Modes – The specific manor or sequence of events that result in functional failure (What caused the component to fail).

Source: Doug Plucknette, GPAllied
The 7 steps of Reliability Centered Maintenance, cont’d

4) Failure Effects – What happens when each failure mode occurs? Events that lead to failure – First sign of evidence – Secondary damage – Action required to return to normal operating condition.

5) Failure Consequences – How does the failure impact your business? (Hidden, EHS, Operational, Non-operational)

Source: Doug Plucknette, GPAlied
The 7 steps of Reliability Centered Maintenance, cont’d

6) Develop Maintenance Task – What task/tasks are best suited to mitigate the failure mode?

7) Reduce Consequences – What can be done to reduce the consequences of failures where there is no scheduled maintenance task? (Consequence Reduction Tasks)
Failure Modes Effects and Criticality Analysis (FMECA)

Annex N.6.1 of NFPA 70B States:

“Part of an effective RCM program is to determine the failure modes and conduct a criticality analysis of all systems. Determine the risk priority based on the product of the severity level of a component, failure occurrence level, and detection level”

Source: NFPA 70B, 2010
We Don’t Know What We Don’t Know!

• It is imperative that we learn from our failures as well as our successes.
• Analyzing failures is absolutely imperative if we want to build a world class maintenance program.
• There are several tools available to allow failures to be analyzed, amongst them are RCA and FRACAS.

Source: FRACAS: Ricky Smith – Bill Keeter
RCA (Root Cause Analysis)

- An Evidence driven process that, at a minimum, uncovers underlying truths about past adverse events, thereby exposing opportunities for making lasting improvements

- **3 common approaches:**
  - 5 Whys
  - Cause and Effect Diagram with the Addition of Cards (CEDAC)
  - RCA

Failure Reporting Analysis and Corrective Action System (FRACAS)

“FRACAS provides a process by which failures can be reported in a timely manner, analyzed, and a corrective action system put in place in order to eliminate or mitigate recurrence of a failure”

Source: FRACAS: Ricky Smith – Bill Keeter
Step by Step RCM Analysis

Utility Feed to Customer

Site / Utility Transformer

Switch Gear

3 Section MCC

Floor Level Panel with Disconnect

≥ 50/60 A

≥ 50 Hp

Buss Disconnect

≥ 125 KvA Transformer
RCM Analysis on 480V Switchgear

MCC 2
A1 – 480 V MOTOR
A2 – 480 / 277 V LIGHTING PANEL
A3 – 480 V SITE SECURITY SWITCH GEAR
A4 –
B1 – 480 V MOTOR
B2 – 480 FEEDER TO SITE IT ELECTRICAL INFRASTRUCTURE
B3 –
B4 – BUS DISCONNECT
C1 – 480 V MOTOR
C2 –
C3 –
C4 –
Step by Step RCM Analysis on 480V Switchgear Example

• **Function**
  – To be able to supply 480 volt, 3 phase electrical power while meeting all power quality, health, safety and environmental standards.

• **Functional Failure**
  – Unable to supply power at all

• **Failure Mode**
  – Motor Control Center door gasket leaks due to embrittlement
  – Motor control wiring fails due to loose connections
  – Bus Bar, Control wiring and terminal connection wiring fails due to insulation breakdown
  – Main Drive Motor Bearings fail due to lack of lubrication
  – Main power fuse clips are loose due to physical damage

Source: Doug Plucknette, GPAllied
To be able to supply 480 volt, 3 phase electrical power while meeting all power quality, health, safety and environmental standards.

**Function # 1**

**Function Failure:** Unable to supply power at all

**Failure Mode:** Bus Bar, Control wiring and terminal connection wiring fails due to insulation breakdown

**Probability of Failure:** M

**Failure Symptom:** Overload Alarm

**Failure Effect:** Insulation breakdown can lead to an opening of the main breaker feeding the Motor Control Center and loss of all MCC loads or the shutdown of the individual bucket and its

**Task:** Set up an annual Ultrasonic PM to do check all conductors for evidence of corona, arcing and/or

**Predictive/Preventive**

**Task to be done by:** Diagnostic Tech

**Interval:** Annual

**Parts Cost:**

**Lead Time:**

**Stock or Buy:**

Source: Doug Plucknette, GPAllied
To be able to supply 480 volt, 3 phase electrical power while meeting all power quality, health, safety and environmental standards.

<table>
<thead>
<tr>
<th>Function #</th>
<th>Function</th>
<th>FF #</th>
<th>FF Function Failure</th>
<th>FM #</th>
<th>FM Failure Mode</th>
<th>Failure Symptom</th>
<th>Failure Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>E</td>
<td></td>
<td>Loss of Power Alarms</td>
<td>Physical damage of the fuse clips results in loose connections and increased heat. If left to its own devices the fuse will burn open and electrical power will be lost.</td>
</tr>
</tbody>
</table>

Task: **Set up a PdM task for every 3 yrs to do Infrared scan of all main breaker fuse components**

<table>
<thead>
<tr>
<th>Predictive/ Preventive</th>
<th>Task to be done by:</th>
<th>Interval:</th>
<th>Parts Cost:</th>
<th>LeadTime:</th>
<th>Stock or Buy:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diagnostic Tech</td>
<td>3 Years</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Doug Plucknette, GPAAllied
To be able to supply 480 volt, 3 phase electrical power while meeting all power quality, health, safety and environmental standards.

<table>
<thead>
<tr>
<th>Function #</th>
<th>FF #</th>
<th>Function Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>Unable to maintain health, safety, and environmental standards</td>
</tr>
</tbody>
</table>

**Failure Mode:** Incorrect sized (Over Rated) overloads have been installed

**Probability of Failure:** L  
**Failure Symptom:** Hidden

**Failure Effect:** In the event incorrect sized overloads have been installed and a overload condition were to exist, electrical power would not disconnect.

**Frequency:** Never on this m  
**Downtime:** 8 hrs  
**Consequences of Failure:** H

- [ ] Evident To Operator
- [ ] Safety/Environment
- [ ] Economic/Operation

**Task:** Set up a failure finding task to verify that the proper sized overloads are installed in each bucket on a annual basis.

- [ ] Redesign
- [ ] Consequence Reduction Task

**Predictive/ Preventive:**
- **Task to be done by:** Electrician
- **Interval:** Annual

**Parts Cost:**

**Lead Time:**

**Stock or Buy:**

---

Source: Doug Plucknette, GPAlied
## FMECA Worksheet

### Motor Control Center

<table>
<thead>
<tr>
<th>Function</th>
<th>Information Worksheet</th>
<th>Failure Mode</th>
<th>Frequency</th>
<th>Evident During Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>Downtime</td>
<td>Probability of Failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Failure Effect</td>
<td>M</td>
<td>Economic</td>
</tr>
</tbody>
</table>

1. **To be able to supply 480 volt, 3 phase electrical power while meeting all power quality, health, safety and environmental standards.**
   - Unable to supply power at all

**Task**

1. **Motor Control Center door gasket leaks due to embrittlement.**
   - Embrittlement of the MCC door gasket results in the gasket material becoming stiff and brittle. If left to its own devices the door gasket will leak. Moisture, dirt and dust could enter resulting in increased resistance, heat eventual the wiring will burn open and short to ground. Hot spots in electrical cabinets are a safety hazard.
   - The plant operator would notice a overload alarm and contact maintenance to troubleshoot and repair.
   - Set up a annual PM task to inspect MCC door gaskets for evidence of embrittlement + hardness or cracking. Replace if noted.

<table>
<thead>
<tr>
<th>Failure Effect</th>
<th>1 time in 10 years</th>
<th>4 hrs</th>
<th>M</th>
<th>Yes</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

2. **Motor control wiring fails due to loose connections.**
   - Loose wiring connections resulting increased heat and resistance. If left to its own devices the connection will burn open and short to ground. This is a safety hazard.
   - The operator will receive a overload alarm and contact maintenance for repair.
   - Perform Quarterly Ultrasonic test of MCC panel for evidence of corona, arching or tracking.
   - Perform quarterly IR inspection of MCC panel for loose connections. Repair/Tighten as noted.

<table>
<thead>
<tr>
<th>Failure Effect</th>
<th>1 time in 1 year</th>
<th>2 hrs</th>
<th>H</th>
<th>Yes</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>
Recap: NFPA Standard 70B 2010

• While the NFPA 70B standard develop a good starting point for creating a complete maintenance strategy, it should be understood that the tasks identified in the standard make a few assumptions:
  – Your equipment was properly designed
  – Your equipment was properly installed
  – Your equipment has been maintained to these standard’s
Electrical Safety Standards and Compliance.
How they Co-ordinate with Your Electrical Maintenance Program?
Incident Pyramid

1

10

100

1000

10000

100000

Fatality

Disabling Injuries

Recordable Injuries

1st Aid Cases

Near-miss Incidents

Hazardous Tasks

Source: Commonly used update to the Safety Pyramid: W.H. Heinrich, 1931
Arc Flash Pyramid

- **Fatality**: 1
- **Incurable Burns Over ½ of Body**: 6
- **Burn Injuries**: 20
- **Arc Flash Incidents**: 85

Source: Data derived from research by CapSchell, Inc.
Arc Flash Incident Pyramid

- Fatality
- Disabling Injuries
- Recordable Injuries
- 1st Aid Cases
- Near-Miss Incidents
- Hazardous Tasks

Comparison | General EHS | Arc Flash |
---|---|---|
Near-Miss : Fatality | 10 000 : 1 | 85 : 1 |
Near Miss : Disabling Injury | 10 000 : 1 | 85 : 6 |
Injury : Fatality | 1 000 : 1 | 20 : 1 |
Hierarchy of Control

Fundamental Principal Upon Which 70E and OSHA are Based

• Control Risk Wherever Practical:
  1. Eliminate the Hazard
  2. Reduce the Risk by Design
  3. Apply Safeguards
  4. Implement Administrative Controls
  5. Use PPE
Don’t Work Live!

• The Department of Labor estimates that there are, on average, 9,600 serious electrical shock and burn injuries every year.
• They also estimate approximately one fatality per day due to electrocution.
• 80% of electrical workers have worked live on sites that they identified as being a high or above average risk.

Source: Mike Doherty - IHSA
Statistics

• 76% identified that the circuits they were working on were not disconnected, and yet...

• 44% of these workers felt they could do this work without injury or serious harm, and...

• 70% have worked on live 347 (277) volt circuits without demanding any form of risk-prevention.

Source: Mike Doherty - IHSA
It’s Just The Way We Do Things!?

• The “tradition” of working live has been the norm for over 100 years, but does that make it acceptable to risk not only the lives of the workers, but the well-being of their families?
NFPA 70E

Standard for Electrical Safety in the Workplace

• Established in 1976 to assist OSHA in developing electrical safety standards

• 2007 OSHA stated that it will
  – “draw heavily form” aspects of 70E and NEC in a rare revision of 1910.303 Subpart S
NFPA 70E, cont’d

**NOT** “the standard that tells you to use PPE.

It’s the standard that says:

– “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.”
NFPA 70E, cont’d

• Training Requirements
• Tasks Restricted to Qualified Personnel
• Electrically Safe Work Conditions
  – LOTO Requirements
• If Not Feasible or Greater Hazard
  – Electrical Hazard and Arc Flash Analysis
  – Energized Electrical Work Permits
  – Prescribed PPE Consistent with the Hazard
• Safety Related Maintenance Requirements
• Safety Requirements for Special Equipment
NFPA 70E Boundaries

Flash protection boundary
Limited approach boundary
Restricted approach boundary
Restricted space
Any point on an exposed, energized electrical conductor or circuit part
Prohibited space
Prohibited approach boundary

Flash protection boundary:
An approach limit at a distance from exposed live parts within which a person could receive a second degree burn if an electric arc flash were to occur (NFPA 70E).

Source: NFPA 70E, Fig. A-1-2.4
NFPA 70E, cont’d

Electrically Safe Work Condition
• Prior to working within the Limited Approach Boundary
• 50 volts or more
• Exemptions
  – Greater Hazard
  – Infeasibility
    • Performing diagnostics and testing on electrical circuits that can only be performed with the circuit energized
    • Work on circuits that are part of a continuous process that would otherwise have to be shut down
NFPA 70E, cont’d

When De-energized Work is not Possible:

• **Energized Electrical Work Permit is Required**
  – Work performed within the Restricted Approach Boundary
  – Exemption made for testing, troubleshooting voltage measurement, etc.; and for visual inspection outside the Restricted Approach Boundary

• **Document Shock Hazard Analysis**

• **Document Arc Flash Hazard Analysis**

• **Document Personal Protective Equipment (PPE) Required**
NFPA 70E, cont’d

When is 70E Applicable?

• Workers Exposed to Energized Electrical Conductors or Circuit Parts
• Risk-Increasing Behavior
• Reason to Believe that Equipment Could Experience a Sudden Change in State
“The collective experience of the task group is that in most cases closed doors do not provide enough protection to eliminate the need for PPE for instances where the state of the equipment is known to readily change (e.g., doors open or closed, rack in or rack out).”

- 70E: 130.7(C)(9) FPN No. 2
### NFPA 70E, cont’d

**Table 130.7(C)(11)**

<table>
<thead>
<tr>
<th>Hazard/Risk Category</th>
<th>Clothing Description</th>
<th>Min. Arc Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Nonmelting, flammable materials (i.e., untreated cotton, wool, rayon, or silk, or blends of these materials) with fabric weight of less than 4.5 oz/yd²</td>
<td>n/a</td>
</tr>
<tr>
<td>1</td>
<td>Arc-rated FR shirt &amp; FR pants or FR coverall</td>
<td>4 cal/cm²</td>
</tr>
<tr>
<td>2</td>
<td>Arc-rated FR shirt &amp; FR pants or FR coverall</td>
<td>8 cal/cm²</td>
</tr>
<tr>
<td>3</td>
<td>Arc-rated FR shirt &amp; pants or FR coverall, and arc flash suit selected so that the system arc rating meets the required minimum</td>
<td>25 cal/cm²</td>
</tr>
<tr>
<td>4</td>
<td>Arc-rated FR shirt &amp; pants or FR coverall, and arc flash suit selected so that the system arc rating meets the required minimum</td>
<td>40 cal/cm²</td>
</tr>
</tbody>
</table>
# NFPA 70E, cont’d

<table>
<thead>
<tr>
<th>Metal Clad Switchgear 1 kV to 38 kV</th>
<th>Exposed</th>
<th>Risk-Increasing</th>
<th>Hazard /Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removal of Bolted Covers</td>
<td>Yes</td>
<td>Yes</td>
<td>4</td>
</tr>
<tr>
<td>Opening Hinged Covers</td>
<td>Yes</td>
<td>Yes</td>
<td>3</td>
</tr>
<tr>
<td>CB Operation with Enclosure Doors Open</td>
<td>Yes</td>
<td>Yes</td>
<td>4</td>
</tr>
<tr>
<td>CB Operation with Enclosure Doors Closed</td>
<td>No</td>
<td>Yes</td>
<td>2</td>
</tr>
<tr>
<td>Performing Thermography Outside the Restricted Area</td>
<td>Yes</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>Reading a Panel Meter While Operating a Meter Switch</td>
<td>No</td>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>
CSA Z462 - Annex “B”
B.1 General

• Regularly scheduled electrical maintenance is a critical part of any electrical safety program.
• Improper equipment operation can drastically increase the risk of worker exposure to electrical hazards.
• Studies by the Electrical Safety Authority of Ontario indicate that 66% of safety incidents can be attributed to maintenance-related issues.

Source: Mike Doherty - IHSA
Arc Flash Hazard Analysis

• Improper or inadequate maintenance can result in increased opening time of the overcurrent protective device, thus increasing the incident energy.
A survey performed by the International Electrical Testing Association (NETA) in October 2007 indicated that 22% of service-aged circuit breakers had some type of malfunction and 10.5% did not operate at all during maintenance testing.
WARNING

Arc Flash and Shock Hazard
Appropriate PPE Required

3 ft. 11
Flash Hazard Boundary

108.8
Cal/cm² Flash Hazard at 18 inches

Extreme
PPE Level

Extremely Dangerous, No PPE Class Found

0.48
kV Shock Hazard when cover is removed

3ft. 6in.
Limited Approach

1ft. 0in.
Restricted Approach

0ft. 1in.
Prohibited Approach

Equipment Name: 4055-050-952
05/25/2007

#EZ45W-AF EZMAKE® SIGN SYSTEM SAFETYCAL INC. - www.safetycal.com - 1-800-446-3525
The role of world class “Electrical Safe Work Planning” concepts and the similarities to world class “Maintenance Programs”
• “Proactive electrical safety maintenance recognizes and addresses situations to prevent them from ever becoming urgent problems and/or injuries”

• You already know how to do this!

Source: Mike Doherty - IHSA
Scenario

480 volt Motor Control Center

Task

1) Troubleshoot and inspect defective starter
(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 of energized electrical conductors and circuit parts operating at 50 volts or more or where an electrical hazard exists. The procedure shall identify the hazard/risk process that shall be used by employees to evaluate tasks before work is started.

- 480 volts direct contact
- 120 volts direct contact
- 480 volt arc flash / blast

Source: Mike Doherty - IHSA
### Table 130.7(C)(9) Continued

<table>
<thead>
<tr>
<th>Tasks Performed on Energized Equipment</th>
<th>Hazard/Risk Category</th>
<th>Rubber Insulating Gloves</th>
<th>Insulated and Insulating Hand Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB or fused switch operation with covers off</td>
<td>1</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Work on energized electrical conductors and circuit parts, including voltage testing</td>
<td>2*</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard or switchboard</td>
<td>2*</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>600 V Class Motor Control Centers (MCCs) — Note 2 (except as indicated)</td>
<td>1</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Perform infrared thermography and other non-contact inspections outside the restricted approach boundary</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>CB or fused switch or starter operation with enclosure doors closed</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Reading a panel meter while operating a meter switch</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>CB or fused switch or starter operation with enclosure doors open</td>
<td>1</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Work on energized electrical conductors and circuit parts, including voltage testing</td>
<td>2*</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

**HRC 2**

**INSULATED TOOLS**

**VR GLOVES**

- **IEEE 1584**
  - 130.7(C)(9) – Task Tables
• Comprehensive Voltage Checks
• PPE
• Approach Boundaries
• Alerting Techniques

110.8 Working While Exposed to Electrical Hazards.

(A) General. Safety-related work practices shall be used to safeguard employees from injury while they are exposed to electrical hazards from electrical conductors or circuit parts that are or can become energized. The specific safety-related work practices shall be consistent with the nature and extent of the associated electrical hazards.
See 110.7, Electrical Safety Program.

E.1 Typical Electrical Safety Program Principles. Electrical safety program principles include, but are not limited to, the following:

(1) Inspect/evaluate the electrical equipment
(2) Maintain the electrical equipment’s insulation and enclosure integrity
(3) Plan every job and document first-time procedures
(4) Deenergize, if possible (see 120.1)
(5) Anticipate unexpected events
(6) Identify and minimize the hazard
(7) Protect the employee from shock, burn, blast, and other hazards due to the working environment
(8) Use the right tools for the job
(9) Assess people’s abilities
(10) Audit these principles
(G) **Job Briefing.**

(1) **General.** Before starting each job, the employee in charge shall conduct a job briefing with the employees involved. The briefing shall cover such subjects as hazards associated with the job, work procedures involved, special precautions, energy source controls, and personal protective equipment requirements.
Moral, Social and Economic Costs

• Myriad of costs involved with significant electrical injury in the workplace
• Electrical injury caused by poor maintenance activities is costly, its lose, lose, lose.
• Owners, managers, supervisors and workers all pay the costs.
Consequences – How Long to Recover?
Consequences To Your Business?

- Energy utilization
- On time delivery
- Environmental releases
- Employee safety
- Raw material utilization
- First pass yield
- Operations uptime

All depend on reliable, incident-free operation of electrical systems!

Source: Lanny Floyd - DuPont
A Few Facts...

- 1400 insured fire losses from electrical failures cost $1 billion between 1992-2001.¹
- Power disruption costs US businesses $80 billion/year.²
- 50% of electrical deaths and severe injuries are associated with routine maintenance & repair.¹

A Few More Facts...Contributors To Electrical Systems Failures

- Loose connections / parts 30.3%
- Moisture 17.4%
- Line disturbance (other than lightning) 10.4%
- Defective / inadequate insulation 9.9%
- Lightning 8.1%
- Foreign objects / short circuiting 7.3%
- Collision 3.9%
- Overloading / inadequate capacity 2.4%
- Accumulation of dust, dirt and oil 2.2%
- All other causes 8.1%

Source: Failures Based on Hartford Steam Boiler Claims Data
Electrical Reliability Involves:

- Paying Attention to equipment, systems, and people!

**Equipment**
- Motors
- Switchgear
- Circuit breakers
- Etc., etc.

**Systems**
- Control
- Protection
- Emergency power
- Etc., etc.

**People**
- Managers
- Engineers
- Technicians
- Operators
- Etc., etc.

Source: Lanny Floyd - DuPont
It’s NOT Just Hardware Equipment!

Source: Lanny Floyd - DuPont
Electrical Systems Reliability – Human Error

Trend in Switchgear Incidents* in one company

*Switching errors resulting in unplanned disruption to operations
Create An Extraordinary Collaboration

- **Safety Professionals**
  - Skill set in safety management systems, risk management, human error

- **Technical experts: Engineers, Electricians, Technicians**
  - Skill set in design, construction, maintenance, operation of electrical equipment and systems
  - Skill in maintenance management systems

- **Management**
  - Responsible for managing priorities, resources, and business objectives

Source: Lanny Floyd - DuPont
Tools and Resources

- NFPA 70B
  Recommended Practice for
  Electrical Equipment
  Maintenance
  2010 Edition

- IEEE
  IEEE Guide for
  Maintenance,
  Operation, and
  Safety of Industrial
  and Commercial
  Power Systems

- NFPA 70E
  Standard for
  Electrical Safety in the
  Workplace

- NETA
  Standard for
  Maintenance
  Testing
  Specifications
  for Electrical Power Distribution
  Equipment and Systems

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Inherently Safer Maintenance Technologies
Conclusion
Opportunities

• Does your maintenance program and practices identify and prioritize equipment critical to electrical reliability?

• Do you design new facilities to incorporate application of electrical PdM maintenance technologies?

• How well have you integrated electric power equipment into your business decisions addressing maintenance management systems?
Take A Critical Look at Your Approach to Electrical Maintenance

• Is it aligned with your organization’s dependence on uptime and reliability of critical electrical energy and control systems?
One Bite at a Time!!!!

- Standards like NFPA 70E, CSZA 462 and NFPA 70B are their to help you build the framework for a successful and safe electrical maintenance program.
- RCM processes are time consuming and require a disciplined and determined management team to ensure successful implementation.
- 90% of RCM programs fail on implementation.
- Consider using outside resources to assist in getting your RCM team trained in the processes involved in setting up your EMP.
- Create your own “Extraordinary Collaboration” the rewards will benefit every area of your business... especially the bottom line.
QUESTIONS?

Stop by our booth during the show and ask any of our technical professionals or e-mail your questions to: info@iriss.com