Electrical Preventative Maintenance (EPM)

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Agenda

- Introduction / Statistics
- What is EPM?
- Benefits of EPM
- EPM Program Components
- Planning an EPM Program
- EPM Fundamentals
- EPM Testing Methods
- Procedural / Safety Practices
- Items To Consider
- Conclusion
- EPM References
- References
- Questions
All Preventative Maintenance Recommendations Are General Guidelines and Are Not Intended To Be Exhaustive or Complete, Nor Are They Designed To Replace Information or Instructions From The Manufacturer of Your Equipment. Contact Your Equipment Service Representative or Manufacturer For Specific Questions Related To Your Equipment.

All Safety Recommendations Are General Guidelines and Are Not Intended To Be Exhaustive or Complete, Nor Are They Designed To Replace Information or Requirements of Your Electrical Safety Program. The Responsibility For Developing An Electrical Safety Program and Ensuring Compliance With Applicable Regulations As They Relate To The Operation and Maintenance of Electrical Distribution Systems and Equipment Solely Resides With The Owner / Host Employer of The Facility.
Introduction / Statistics

- Electrical Systems Begin To Deteriorate Once They Are Built / Installed
- Performance and Life Expectancy of Electrical Systems Decline With Environmental Conditions, Overload Conditions, and Excessive Duty Cycles
- Principal Reason For Electrical System Failure Is Failure To Maintain
- Dependable Designs Require Maintenance To Keep Them Dependable
- Average of Six (6) Hours of Business Interruption Caused By Each Electrical Failure In Your Electrical System - (Laskey 2012)
- Failure Rate Is Three (3x) Higher For Electrical Equipment That Is Not Part of An Electrical Preventative Program - (HSB 2010)
- The Risk of An Unscheduled Electrical Failure Can Be Reduced By 66% With An Effective Preventative Maintenance Program - (HSB 2010)
### Top Causes of Electrical Distribution System Failure

<table>
<thead>
<tr>
<th>Cause</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loose Connections / Parts</td>
<td>30.3%</td>
</tr>
<tr>
<td>Moisture</td>
<td>17.4%</td>
</tr>
<tr>
<td>Line Disturbance (Other Than Lightning)</td>
<td>10.4%</td>
</tr>
<tr>
<td>Defective / Inadequate Insulation</td>
<td>9.9%</td>
</tr>
<tr>
<td>Lightning</td>
<td>8.1%</td>
</tr>
<tr>
<td>Foreign Objects / Short Circuiting</td>
<td>7.3%</td>
</tr>
<tr>
<td>Collision</td>
<td>3.9%</td>
</tr>
<tr>
<td>Overloading / Inadequate Capacity</td>
<td>2.4%</td>
</tr>
<tr>
<td>Dust / Dirt / Oil Accumulation</td>
<td>2.2%</td>
</tr>
<tr>
<td>All Other Causes</td>
<td>8.1%</td>
</tr>
</tbody>
</table>

Failures Based on Hartford Steam Boiler Claims Data
What is EPM?

- Process of Inspecting, Testing, Analyzing, Servicing, and Mitigating Risks Associated with Electrical Systems and Equipment With The Purpose of Maintaining Safe Operations and Production By Reducing or Eliminating System Interruptions or Equipment Breakdown
Benefits of EPM

- Improves Safety For Facility and Technicians
  - Provides Assurance That Protective Devices Will Function
    - Safely Clears Fault Conditions (Short Circuits, Overloading, Ground Faults, etc.)
  - Arc-Flash Calculations Assume Equipment Is Maintained
    - Calculation Required For Operation / Inspection and Selection of Proper PPE

- Provides Higher Level of Reliability / Dependability
  - Reduces Risk of Equipment / System Failure
    - Minimizes Property Loss Claims / Lowers Insurance Premiums
  - Minimizes Losses in Production / Service To Customers

- Strengthens Operational Learning / Training of Electrical System
  - Observe Reactions of Electrical, Mechanical, and Control Systems

- Enables Equipment / System To Operate At Peak Efficiency
  - 1% - 3% Energy Savings Over Non-Maintained Equipment

- Assists With Diagnostic / Troubleshooting
  - Provides State of Equipment at a Particular Date / Time
Benefits of EPM (Cont.)

- Controls Equipment Repair / Replacement Expenses
  - Equipment Maintenance Can Be Budgeted / Tracked
  - Implement Changes / Correct Deficiencies Under Controlled Conditions
  - Reduces Emergency Repair / Replacement Expenditures
    - Approximately Three (3x) Cost To Fix The Same Problem

Annual Maintenance Costs vs. Time

NFPA 70B – Figure 4.2.6
EPM Program Components

✦ Qualified Personnel
  – Technical Competence
    • Understand / Update One-Line / P&ID Diagrams & Equipment Layouts
    • Survey / Analyze Condition / Criticality Nature of Equipment
    • Knowledge of Associated Mechanical / Control Processes / Systems
    • Generate Detailed Methods of Procedure’s (MOP)
    • Generate Daily Walk-Thru Checklists / Emergency Procedures
    • Assess System Hazards (Arc-Flash, Environmental)
    • Understand / Update System Studies (Coordination, TCC’s, Arc-Flash)
    • Inspect Equipment for Physical Signs of Damage
    • Ability to Make Decisions During Procedures

  – Administrative / Supervisory Competence
    • Planning and Development of Long Range System Objectives
    • Communicate With Management / Customers / Technicians
    • Execute Methods of Procedure’s (MOP)
    • Manage and Supervise Technicians / Contractors
    • Keep Track of Budgets / Invoicing / Follow-up With Action Items
    • Manage O&M Manuals and Manufacturer Wiring Diagrams
    • Serve as Electrical Systems Coordinator (ESC) During Procedures
    • Ability To Make Decisions During Procedures
EPM Program Components (Cont.)

- Routine Inspections (Regularly Scheduled)
  - Daily Walk-Throughs / Checklists

- Detailed Inspections / Testing (Programmed Scheduled)
  - Database Management Tools (DataStream 7i)

- Analysis of Testing Reports
  - Both Current and Past
  - Recommended Corrective Measures / Action Items

- Implementation of Corrective Measures / Action Items

- Record Keeping / Trending
  - Database Management Tools (DataStream 7i)
  - Both Hard & Soft Copies

Typical Action Items List

<table>
<thead>
<tr>
<th>Item Number</th>
<th>System/Process/Equipment</th>
<th>Issue/Action Item Required</th>
<th>Responsible Party</th>
<th>Priority</th>
<th>Status</th>
<th>Completion Date</th>
<th>Comments</th>
</tr>
</thead>
</table>

Duke Facilities Management Utilities & Engineering Services
Planning an EPM Program

- Gather Support / Funding / Commitment From Management
- Survey All Systems / Equipment
- Perform Failure Mode Effects Analysis (FMEA)
  - Safety of Personnel / Technicians
  - Uniqueness of System / Equipment
  - Impacts to Production / Service To Customers
    - System / Equipment Redundancy (N+1)
- Determine Maintenance Intervals Based On The Following
  - Importance / Critical Nature of Equipment
  - Requirements of Manufacturer
  - Age of Equipment
  - Number of Operations / Duty Cycle
  - Demand / Load Conditions
  - Environment
Determine Resources / Staffing Requirements

- Management of Program Shall Always Be Performed Internally
- Timeline to Perform Maintenance (1 Week or 3 Months)
- Insourcing
  - Ownership / Calibration of Equipment
  - Size of System
  - Impact to Production / Service to Customers
- Outsourcing
  - Define Scope of Work / Testing Specification
  - Regularly Engaged In Electrical Testing (Minimal of 5 Yrs.)
  - NETA Certified / OSHA Trained / NFPA 70E Trained
  - Proof of Equipment Calibration Program
- EPM From Maintenance Department of Equipment Manufacturer
  - Specialty Items
- EPM From Independent Testing Firm
  - Knowledge of Numerous Manufacturers
### Duke University Utility Plant Maintenance

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CP1</td>
<td>CP2</td>
<td>ECSP</td>
<td>WCSP</td>
</tr>
<tr>
<td>SWGR / Breakers / Panels / Transformers / Switches / Motors</td>
<td>1X</td>
<td></td>
<td>1X</td>
<td></td>
</tr>
<tr>
<td>Starters / VFD’s</td>
<td>1X</td>
<td>1X</td>
<td>1X</td>
<td>1X</td>
</tr>
<tr>
<td>UPS</td>
<td>2X</td>
<td>2X</td>
<td>2X</td>
<td>2X</td>
</tr>
<tr>
<td>Generators</td>
<td>1X</td>
<td>1X</td>
<td>1X</td>
<td>1X</td>
</tr>
<tr>
<td>Generators (Load Test)</td>
<td>12X</td>
<td>12X</td>
<td>12X</td>
<td>12X</td>
</tr>
<tr>
<td>Inspection (Status / Alarms)</td>
<td>365X</td>
<td>365X</td>
<td>365X</td>
<td>365X</td>
</tr>
</tbody>
</table>
Keep It Tight

- Cause / Effect
  - Vibration, Expansion / Contraction of Components With Load
  - Increases Contact Resistance, Produces Abnormal System Reactions
- Infrared Survey
  - Requires Exposure To Arc-Flash Hazard
- Torque Wrench
  - Tighten To Manufacturers Recommendations
- Low Resistance Ohmmeter (DLRO)
  - Valuable For Concealed Bussing

Keep It Dry

- Cause / Effects
  - Humidity, Condensation, Chemicals, Oils, Etc.
  - Accelerates Oxidation Process, Increases Contact Resistance, Shorts Equipment
- Wipe Down
  - Lint-Free Rags
  - Cleaning Agent (Non-Flammable, Non-Corrosive To Electrical Materials)
Keep It Clean

- **Cause / Effect**
  - Dirt, Dust, Lint, Chemicals, Metallic Particles, Oils, Etc.
  - Clogs Equipment Cooling Means, Creates Fire Hazards, Increases Contact Resistance
- **Wipe Down**
  - Lint-Free Rags
  - Cleaning Agent (Non-Flammable, Non-Corrosive To Electrical Materials)
- **Vacuum / Brush**
  - NEVER Use Compressed Air
- **Change Air Filters**
  - Washable Filters Shall Be Dry Before Being Placed In Service

Keep It Friction Free

- **Cause / Effect**
  - Prohibits Operation of Equipment, Increases AF Hazard, Increases Contact Resistance
- **Lubricating Spray**
  - Non-Flammable, Non-Corrosive To Electrical Materials
- **Contact Grease**
Other Fundamentals

- Cover All Holes / Unused Penetrations
  - Arc-Flash Hazard From Falling Foreign Objects
  - Foreign Animals (Ants, Rats, Squirrels, Snakes, etc.)

- Keep Insulators Away From Sharp Objects
Insulation Resistance (IR) Testing
- Measures the Quality / Resistance of an Insulator Relative to Adjacent Reference Points
- General Terms: Hi-Pot, Megger

Installation (IR) Testing
- Verify Rating of Component / Proper Installation
- Typically Performed at 1.7x Rated Voltage

Maintenance (IR) Testing
- Verify Present and Future State of Component
- Typically Performed at Rated Voltage

Method / Metrics
- Test L-L and L-G For All Phases
- Metrics
  - Resistance Should Be High and Increase Over Time
  - Di-Electric Absorption Ratio (1 min / 30 sec)
  - Polarization Index (10 min / 1 min)
  - Minimum DE Absorption Ratio / PI Value =1.0

Typical Components
- SWGR, Panels, Tap Busses, Conductors, Transformer Windings, Breakers, Switches, Motor Controllers / Starters, Motor Windings, Insulators, Barriers, etc.
Contact Resistance Testing
- Measures the Resistance Across a Component
- General Term: DLRO

Metrics
- Resistance Should Be Low and Remain Stable
- Test All Phases / Components / Lineups

Typical Components
- SWGR, Panels, Tap Busses, Breakers, Switches, Motor Controllers / Starters, Fuses, Contacts, etc.
- VERY Useful for Concealed Bussing

Secondary Current Injection (SCI) Testing
- Measures the Operating Time of a Protective Device At A Specified Current Level
- ONLY Tests The Trip Unit. Does NOT Test The Entire Protective Device (CT’s, Pickups, etc.)
- Requires Time-Current Curve of Protective Device

Typical Components
- Relays, Breakers
Primary Current Injection (PCI) Testing
- Measures the Operating Time of a Protective Device At A Specified Current Level
- Verifies Operation of The Entire Protective Device
- Requires Time-Current Curve of Protective Device

Method / Metrics
- Test All Phases
- Test All Settings (LT, ST, INST, GF, etc.)
- Test MCCB’s Without Removal
- Metrics
  - % Range Above or Below Curve Characteristics

Typical Components
- Breakers(100A and Above)
- NOT Performed On Fuses

Notes
- Verify Adequate Space / Structure (1200 lbs.)
- Separate / Independent Power Source
  - Approximately 150 kVA
    - (225A at 480V / 400A at 208V)
Transformer Turns Ratio (TTR) Testing
- Measures the Turns Ratio Between the Primary and Secondary Windings
- Typical Components: Transformers

Power Factor (PF) Testing
- Measures the Dryness of an Insulator Relative to Adjacent Reference Points
- Typical Components: Transformers

Oil Sampling
- Measures Levels of the Following:
  - Acidity
  - Di-Electric Breakdown
  - Moisture Content
  - Color
  - Power Factor
- Typical Components: Oil-Filled Transformers, Oil-Filled Circuit Breakers / Switches

Calibration of Testing Equipment
- Field Testing Equipment – Every 6 Months
- Laboratory Testing Equipment – Every 12 Months
Procedural / Safety Practices

- Generate Detailed Method of Procedure
  - Must Be Site Specific

- Qualified Personnel as Electrical System Coordinator (ESC)

- Conduct Procedural Overview / Safety Meeting Prior to Work
  - Every Day for Multi-Day Procedures

- All Procedural Tasks Shall Be Directed By The ESC

- No Equipment Shall Be Energized or De-Energized Without ESC Approval

- No Equipment Covers Shall Be Removed Without ESC Approval

- Mark All Equipment That Remains Energized and/or De-Energized

- Utilize Proper Personal Protective Equipment (PPE)
  - Arc-Rated Clothing / Voltage Rated Gloves
  - Insulated Tools / Fiberglass Rods
  - Inspections / Diagnostics / Switching / Verifications / Grounding
LOTO De-Energized Equipment Associated With Procedure
   - All Parties Associated With Procedure Shall Place Lock on Box

Verify Equipment Is De-Energized Prior To Performing Any Work

Discharge Equipment
   - Wait 10 Minutes For Stored Energy (Capacitors) In System To Discharge
   - Verify That Insulation Resistance Test Set Has Draining Capabilities

Ground Equipment
   - Remove Grounds ONLY When Testing Component
   - Remove Grounds Prior to Closing Enclosure

Coordinate Insulation Resistance Testing With All Parties

ESC Shall Perform Final Inspection Prior to Closing All Enclosures
## Procedure / Safety Practices (Cont.)

<table>
<thead>
<tr>
<th>METHOD OF PROCEDURE / LOTO PROCEDURE</th>
<th>LOCATION: DUKE UNIVERSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING / STATION:</td>
<td>CHILLER PLANT #2 / SUBSTATION #5</td>
</tr>
<tr>
<td>PURPOSE:</td>
<td>MAINTENANCE OF ELECTRICAL GEAR</td>
</tr>
<tr>
<td>PREPARED BY:</td>
<td>PAUL WESTRAY</td>
</tr>
<tr>
<td>CHECKED BY:</td>
<td>DARIN SMITH, AUREL SELEZANU, CASH DAVIDSON</td>
</tr>
<tr>
<td>REVISION</td>
<td>0</td>
</tr>
</tbody>
</table>

### PROCEDURE

**Day 1 - January 23, 2012 (Phase I - 480V - Side B)**

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>PLANNED START</th>
<th>PLANNED FINISH</th>
<th>DEPT</th>
<th>PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Verification &amp; Shutdown</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-1</td>
<td>7:30</td>
<td>...</td>
<td>CW</td>
<td>Calculate anticipated CW demand from 1/23</td>
</tr>
<tr>
<td>1-2</td>
<td>...</td>
<td>7:30</td>
<td>CW</td>
<td>Confirm ability to meet CW demand with CP1, CP2 (Side 1A), and CP2 (Sides 2A and 2B)</td>
</tr>
<tr>
<td><strong>Generator Switching</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-3</td>
<td>7:30</td>
<td>...</td>
<td>CW</td>
<td>Safety shut down Day 1 Equipment via SIEMENS controller (Refer to Day 1 One-Line/Equipment List)</td>
</tr>
<tr>
<td>1-4</td>
<td>7:30</td>
<td>...</td>
<td>HV</td>
<td>Rotate Local Control Switch to MANUAL</td>
</tr>
<tr>
<td>1-5</td>
<td>7:40</td>
<td>...</td>
<td>HV</td>
<td>Rotate Generator Control Switch for G4 to OFF</td>
</tr>
<tr>
<td>1-6</td>
<td>7:40</td>
<td>...</td>
<td>HV</td>
<td>Verify 1TB breaker in Substation 1 is open and racked out</td>
</tr>
<tr>
<td><strong>480V Switching and LOTO</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-7</td>
<td>...</td>
<td>...</td>
<td>HV</td>
<td>Provide lock/tag for 1TB breaker in Substation 1. Place key in lock box dedicated to Day 1 Procedures</td>
</tr>
<tr>
<td>1-8</td>
<td>...</td>
<td>...</td>
<td>HV</td>
<td>Open Xfrmr 1B control panel breaker in Panel RP1</td>
</tr>
<tr>
<td>1-9</td>
<td>...</td>
<td>...</td>
<td>UE</td>
<td>Provide lock/tag for Xfrmr 1B control panel breaker in Panel RP1. Place key in lock box dedicated to Day 1 Procedures</td>
</tr>
<tr>
<td><strong>12,470V Switching and LOTO</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-10</td>
<td>7:50</td>
<td>...</td>
<td>HV</td>
<td>Verify absence of load on Side B of Substation 1. DO NOT open any Side B breakers in Substation 1</td>
</tr>
<tr>
<td>1-11</td>
<td>7:50</td>
<td>...</td>
<td>HV</td>
<td>Open HV switch 1B in Substation 1</td>
</tr>
<tr>
<td>1-12</td>
<td>...</td>
<td>...</td>
<td>HV</td>
<td>Open S2-9 breaker in 15kV SWGR 5A</td>
</tr>
<tr>
<td>1-13</td>
<td>...</td>
<td>...</td>
<td>HV</td>
<td>Back out S2-9 breaker in 15kV SWGR 5A</td>
</tr>
<tr>
<td><strong>LOT0</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-14</td>
<td>8:00</td>
<td>...</td>
<td>HV</td>
<td>Provide lock/tag for S2-9 breaker in 15kV SWGR 5A. Place key in lock box dedicated to Day 1 Procedures</td>
</tr>
<tr>
<td>1-15</td>
<td>8:00</td>
<td>8:00</td>
<td>ALL</td>
<td>Provide lock/tag for Day 1 Procedures</td>
</tr>
<tr>
<td><strong>12,470V and 480V Servicing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-16</td>
<td>8:00</td>
<td>...</td>
<td>TC</td>
<td>Inspect, test, and clean S2-9 breaker in 15kV SWGR 5A</td>
</tr>
<tr>
<td>1-17</td>
<td>...</td>
<td>...</td>
<td>TC</td>
<td>Inspect, test, and clean HV switch 1B in Substation 1</td>
</tr>
<tr>
<td>1-18</td>
<td>...</td>
<td>...</td>
<td>TC</td>
<td>Inspect, test, and clean Xfrmr 1B in Substation 1</td>
</tr>
<tr>
<td>1-19</td>
<td>...</td>
<td>...</td>
<td>UE</td>
<td>Review S2-9 breaker data, inspect, and approve</td>
</tr>
<tr>
<td>1-20</td>
<td>...</td>
<td>...</td>
<td>UE</td>
<td>Review HV switch 1B data, inspect, and approve</td>
</tr>
<tr>
<td>1-21</td>
<td>...</td>
<td>...</td>
<td>UE</td>
<td>Review Xfrmr 1B data, inspect, and approve</td>
</tr>
<tr>
<td>1-22</td>
<td>...</td>
<td>...</td>
<td>TC</td>
<td>Inspect, test, and clean Side B in Substation 1</td>
</tr>
<tr>
<td>1-23</td>
<td>...</td>
<td>...</td>
<td>TC</td>
<td>Inspect, test, and clean Side B breakers in Unit Substation 1. (Refer to Day 1 One-Line/Equipment List)</td>
</tr>
<tr>
<td>1-24</td>
<td>...</td>
<td>...</td>
<td>TC</td>
<td>Inspect, test, and clean 1TB (Spare) breaker in Substation 1</td>
</tr>
<tr>
<td>1-25</td>
<td>...</td>
<td>...</td>
<td>TC</td>
<td>Inspect, test, and clean PDP-4</td>
</tr>
<tr>
<td>1-26</td>
<td>...</td>
<td>...</td>
<td>UE</td>
<td>Review Side B data, inspect, and approve</td>
</tr>
<tr>
<td>1-27</td>
<td>...</td>
<td>...</td>
<td>UE</td>
<td>Review Side B breaker data, inspect, and approve</td>
</tr>
<tr>
<td>1-28</td>
<td>...</td>
<td>...</td>
<td>UE</td>
<td>Review 1TB (Spare) breaker data, inspect, and approve</td>
</tr>
<tr>
<td>1-29</td>
<td>...</td>
<td>...</td>
<td>UE</td>
<td>Review PDP-4 data, inspect, and approve</td>
</tr>
<tr>
<td>1-30</td>
<td>...</td>
<td>...</td>
<td>TC</td>
<td>Inspect, test, and clean PDP-1</td>
</tr>
<tr>
<td>1-31</td>
<td>...</td>
<td>...</td>
<td>TC</td>
<td>Inspect, test, and clean MCC-1</td>
</tr>
<tr>
<td>1-32</td>
<td>15:30</td>
<td>...</td>
<td>UE</td>
<td>If PDP-1 and MCC-1 complete, review PDP-1 and MCC-1 data, inspect, and approve</td>
</tr>
</tbody>
</table>
Items To Consider

- Location of Equipment
  - Locate Equipment To An Environment Suited for Electrical Equipment
    - Clean / Dust Free
    - 40% to 70% Relative Humidity
    - 60°F to 85°F Temperature

- Design of Equipment
  - Double-Ended SWGR (MTTM Configuration)
  - Automatic Transfer Switches
  - Drawout Protective Devices
  - Infrared Port Holes
  - Operational Counters
  - Equipment Enclosure To Appropriate NEMA Rating
    - NEMA 4, NEMA 4X, NEMA 12, NEMA 13

- Redundancy
  - Multiple Fan / Pump Assemblies
  - Dedicated / Isolated Silos of Equipment
  - Bypass / Back-feed Critical Equipment
Items To Consider (Cont.)

- **Spare Breakers / Trip Units**
  - Unable To Place System Back In Service If System Fails

- **Temporary Generator Support For Select Components**

- **Dedicated Storage Compartments**
  - *NEVER* Store Miscellaneous Parts / Tools Inside Energized Compartments

- **Miscellaneous**
  - GFCI Protective Devices For All Exterior Circuits

- **Emergency Procedures**
Conclusion

- Benefits of EPM Outweigh Costs / Risks of Equipment Failure
- Assign Qualified Personnel and Allocate Time for EPM Program Mgmt.
- Proper Planning / Implementation Are Critical To A Successful EPM Program
- EPM Fundamentals (Tight, Dry, Clean, Friction Free)
- EPM Testing Methods (IR, CR, PCI, TTR, Sampling, etc.)
- Safety Should Always Be #1 Priority
- Good System Designs Help Reduce The Impacts to Production / Service When Performing EPM
EPM References

- NFPA 70B® Recommended Practice for Electrical Equipment Maintenance
- NETA Standard For Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems
- NFPA 70E® Standard for Electrical Safety in the Workplace
- NESC® National Electrical Safety Code
- NFPA 70® National Electrical Code
- NFPA 110® Standard For Emergency and Standby Power Systems
References


- NFPA 70B®, Recommended Practice for Electrical Equipment Maintenance, 2010 edition

Questions?