IAE-101:
Electrical Fundamentals for Non-Electrical Personnel

Abstract

Today's world of rapidly evolving technology poses a wealth of challenges just to remain competitive in the marketplace. Everyone is attempting to stay abreast of the "latest and greatest;" *but what about the basics, including evaluation of work force utilization?* More and more companies are realizing the need for cross training their maintenance workforce creating competent multi-skilled technicians.

This course addresses cross-over of responsibility for certain electrical tasks by mechanical maintenance personnel. We begin with fundamentals skills, including the proper and safe use of electrical measuring and test instruments and hand tools, such as multi-meters, meggers, and ammeters, wire strippers and crimpers, just to name a few. Safe and proper instruction is conducted in electrical troubleshooting and repair or replacement of industrial electrical motors, motor starters and associated I/O (input/output) devices.

Throughout this seminar, instructor demonstrations are combined with emphasis on safety and extensive student hands-on activities to drive home the key points. Attendees will leave this seminar with a good understanding along with applied learning skills to effectively troubleshoot and repair or replace all elements associated with an industrial motor installation. Proper electrical maintenance principles and procedures will be delivered along with an in depth and separate mandatory 4 hour electrical safety class.

The overall seminar provides safe and practical techniques to ensure that proper electrical maintenance tasks are performed *confidently and correctly the first time.* Root Cause Failure determination processes consistently demonstrate that human error in basic electrical skills is too often the source of a problem.

Problem solving techniques and hands on activities include:

- Electrical test equipment and hand tool selection, use, & precautions
- Basic electrical theory
- Component level troubleshooting procedures
- Handling, installation & repair/replacement procedures of motors, motor starters and I/O devices
- Proper safety practices and procedures
- Reading and understanding electrical schematics
- Reliability based maintenance philosophies and best practices

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Seminar Duration

The duration of this seminar is 24 hours.

- 20 hours of basic electrical theory, troubleshooting and repair/replacement of industrial motors and their associated control
- 4 hours of industrial electrical safety

Who should attend?

This seminar is designed primarily for industrial mechanical technicians and other qualified personnel successfully completing vendor approved skill and ability assessment testing. All personnel whose job functions involve rotating machinery troubleshooting, repair or replacement are urged to attend. The scope of content is appropriate for individuals who provide support for such tasks as overhaul, change-out, repair or restoration of industrial machinery.

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Specific Tasks

1. Properly and safely use the following electrical tools and hardware.
   - Wire stripper
   - Wire crimper
   - Fuse puller
   - Holding screw driver
   - Unilever lockout lock
   - Insulated Tools
   - Continuity Flash light
   - VOM (volt-ohm meter)
   - Voltage tester
   - Clamp-on ammeter
   - Megger

2. In the event of an 3-phase induction electric motor failure, properly and safely identify and troubleshoot the motor and the following associated components and I/O control devices:
   - Starter
   - Fuse Disconnect
   - Associated Input/Output Control Devices
   - Motor Controller

3. Properly and safely remove, repair, and replace the failed motor, associated components, or control devices identified during the troubleshooting.

4. Properly and safely return repaired components to service.

Prerequisites

- Required Electrical Safety Training…OSHA, NFPA-70E, Unilever requirements, LO/TO/TO

Related Tasks

- Motor Installation
- Pre-alignment Checks
- Precision Shaft Alignment
- Precision Belt or Chain Drive Maintenance
- Equipment Commissioning
- Post-repair PdM Checks

Learning Objectives

1. Explain the following maintenance philosophies, including the role each plays in an overall machinery reliability improvement process:

    - Breakdown/Repair
    - Preventive Maintenance (PM)
    - Predictive Maintenance (PdM)
    - Precision Maintenance/Corrective

2. Explain six primary patterns of component failures, including the general percentages of age-related vs. random failures and the impact of these failure patterns on maintenance strategies.

3. Explain fundamental maintenance and reliability best practices used by Unilever, including how this training relates to the work performance and equipment reliability improvement elements of Unilever's Proactive Maintenance Model.

4. Explain and demonstrate proper electrical safety practices as outlined in OSHA, NFPA-70E, Unilever requirements, including, but not limited to, the following:
    - Hazardous Locations
    - Hazard Identification
    - PPE Requirements
    - LO/TO/TO

5. Identify by sight, explain the common uses, and demonstrate proper and safe use of the following electrical tools and hardware.
    - Wire stripper
    - Wire crimper
    - Fuse puller
    - Holding screw driver
    - Unilever lockout lock
    - Insulated Tools
    - Continuity Flash light
    - VOM (volt-ohm meter)
    - Voltage tester
    - Clamp-on ammeter
    - Megger

6. Explain and identify wire sizing, including current capacity and types of insulation.

7. Explain how to select a VOM, ammeter and megger for a given application.

8. Explain and demonstrate the Unilever LO/TO/TO processes utilized at your facility.

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9. Identify different types of electric schematics and explain and demonstrate how to read them for the following purposes:
    - Locate electrical energy sources for motors and associated electrical components and I/O devices.
    - Identify specific components and their specifications.
    - Determine basic system operation.
    - Logically troubleshoot a problem.

10. Define and explain the significance of the following electrical terms and how they relate to troubleshooting and maintaining industrial control systems:
    - Current
    - Voltage
    - Resistance
    - Ohm's Law
    - Electromagnetic fields
    - Power generation
    - Substation
    - MCC (motor control center)
    - 110-volt VAC power distribution panel
    - Grounding Systems

11. Identify the following I/O devices and describe their basic construction and function:
    - Limit Switches
    - Lid Switches
    - Motion Detectors
    - Level Sensors
    - Control Solenoids
    - Control Relays
    - Miscellaneous I/O devices

12. Explain how to properly and safely remove and replace each of the devices listed in objective #11.

13. Explain the interface between the I/O devices listed above and a PLC (programmable logic controller).

Seminar Outline

1. Course overview
    a. Introductions and ground rules
    b. Class goals and objectives
    c. Conduct a pre-assessment exam for this course

2. Reliability Overview
    a. Overview of Unilever's MRP
    b. Maximizing Machinery Reliability Overview
        i. Maintenance Philosophies
        ii. Failure Patterns

3. Basic Electricity
    a. Terminology
    b. Current
    c. Voltage
    d. Resistance
    e. Ohm's Law
    f. Magnetism
        i. Electromagnetic fields
    g. Electrical Distribution overview
        i. Power generation
            1. Single Phase AC
            2. 3 phase AC supply
        ii. Substation
        iii. MCC (motor control center)
        iv. 110 VAC power distribution panel

4. Safety Overview
    a. NFPA-70E
    b. PPE
        i. Safety Glasses
        ii. Gloves
    c. Unilever's LO/TO/TO (lockout/tagout/tryout) procedure
    d. "Hazardous locations" used at Unilever

5. Electrical tools and hardware
    a. Hand Tools
        i. Wire stripper
        ii. Wire crimper
        iii. Fuse puller
        iv. Holding screw driver
        v. Unilever lockout lock
        vi. Insulated Tools
        vii. Continuity Flash light
    b. Measurement tools
        i. Digital VOM (volt-ohm meter)
        ii. Voltage tester

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iii. Clamp-on ammeter
iv. Megger

6. Input and Output Devices
    a. Input devices
        i. Limit switches
            1. Types
            2. Construction
            3. Actuators
            4. Application
            5. Troubleshooting
        ii. Lid switches
            1. Types
            2. Construction
            3. Actuators
            4. Application
            5. Troubleshooting
        iii. Motion detectors
            1. Types
            2. Construction
            3. Actuators
            4. Application
            5. Troubleshooting
        iv. Level sensors (bindicators)
            1. Types
            2. Construction
            3. Actuators
            4. Application
            5. Troubleshooting
        v. Misc. Input Devices
            1. Types
            2. Construction
            3. Actuators
            4. Application
            5. Troubleshooting

    b. Output devices
        i. Control solenoid
            1. Types
            2. Construction
            3. Actuators
            4. Application
            5. Troubleshooting
        ii. Motor starter control relay
            1. Types
            2. Construction
            3. Actuators
            4. Application
            5. Troubleshooting

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iii. Misc. Output Devices
1. Types
2. Construction
3. Actuators
4. Application
5. Troubleshooting

7. 3 phase induction motors and starters
a. AC Induction Motors
i. Construction
1. Frame
2. Stator
3. Poles
4. Junction Box
5. Rotor
6. Bearings
ii. Motor nameplate
1. Horsepower rating
2. FL amps
3. Service Factor
iii. Principle of operation
1. Direction of rotation
iv. Common faults
1. Overheating
2. Overload
3. Ground Faults
4. T-T shorts
5. Single Phasing
v. Proactive Procedures
1. Visual
2. Audible
3. Tactile
4. Cleaning
b. 3 Phase Starters
i. Construction
1. Casing
2. Busbar Stabs
3. Fuse disconnect
4. Manual overloads
5. Heaters
6. Control relay
7. Electrical Interlock
8. Fuse clips
ii. Principle of operation
iii. Motor protection
1. Overload
2. Shorts
3. Ground faults

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4. Single phasing
   iv. Proactive Procedures
      1. Visual
      2. Audible
      3. Smell

c. VFD (variable frequency drive)
   i. Principle of operation
   ii. Construction
      1. Controller
      2. Tacho Generator
      3. Display
   iii. Basic Troubleshooting
      1. digital display
      2. Tacho Generator

8. Electrical Equipment Documentation
   a. Plant marking conventions
      i. Wire marking convention
      ii. Equipment marking convention
   b. Electrical schematics
      i. 1 line diagrams
      ii. Bubble charts
      iii. Distribution panel schematics
         1. Control Breakers
         2. Lighting breakers
      iv. 110 VAC I/O interfacing to a PLC (programmable logic controller)
         1. Indicator lights
         2. control fuses

9. De-Energized hands on exercises and qualification testing
   a. Demonstrate the proper steps of LO/TO/TO (lockout/tagout/tryout)
      i. Written
      ii. Hands on
   b. Read an electrical schematic and identify each component
      i. Written
      ii. Hands on
   c. Describe each piece of data on the motor nameplate
      i. Written
      ii. Hands on
   d. Disconnect a motor, megger its windings and reconnect motor
      i. Written
      ii. Hands on
   e. Identify and replace faulty motor fuse(s)
      i. Written
      ii. Hands on
   f. Identify and replace faulty overload heater(s)
      i. Written

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ii. Hands on

10. Energized circuit hands on exercises and qualification testing
    a. Demonstrate the proper steps of LO/TO/TO (lockout/tagout/tryout)
        i. Written
        ii. Hands on
    b. Read an electrical schematic and identify each component
        i. Written
        ii. Hands on
    c. Describe each piece of data on the motor nameplate
        i. Written
        ii. Hands on
    d. Disconnect a motor, megger its windings and reconnect motor
        i. Written
        ii. Hands on
    e. Identify and replace faulty motor fuse(s)
        i. Written
        ii. Hands on
    f. Identify and replace faulty overload heater(s)
        i. Written
        ii. Hands on

11. Conduct a post assessment exam for this course and discuss results

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