REGISTERED MASTER ELECTRICIAN AFFAIRS COMMITTEE & ELECTRICIAN’S ACADEMY

- presents -
Casimiro Flores, Jr
RME, CPM,
Safety Practitioner
Safety Consultant
Learning Outcomes:

✓ Preventive Maintenance Vs Corrective maintenance
✓ Electrical Preventive Maintenance
✓ Electrical Safety
✓ To have knowledge on how to test the equipment/machine using different types of instruments.
✓ Learn techniques on how to identify common troubles
✓ Sharing of skills and ideas
✓ Fish bone analysis or 5w + 1 H
NFPA 70B, NFPA 70E

NFPA 70B
ELECTRICAL PREVENTIVE MAINTENANCE PROGRAM

NFPA 70E
ELECTRICAL SAFETY IN THE WORKPLACE
1.1 Scope.

1.1.1 This recommended practice applies to preventive maintenance for electrical, electronic, and communication systems and equipment and is not intended to duplicate or supersede instructions that manufacturers normally provide. Systems and equipment covered are typical of those installed in industrial plants, institutional and commercial buildings, and large multifamily residential complexes.

1.1.2 Consumer appliances and equipment intended primarily for use in the home are not included.
• This standard addresses electrical safety-related work practices, safety-related maintenance requirements, and other administrative controls for employee workplaces that are necessary for the practical safeguarding of employees relative to the hazards associated with electrical energy during activities such as the installation, inspection, operation, maintenance, and demolition of electric conductors, electric equipment, signaling and communications conductors and equipment, and raceways.
This standard also includes safe work practices for employees performing other work activities that can expose them to electrical hazards as well as safe work practices for the following:

(1) Installation of conductors and equipment that connect to the supply of electricity

(2) Installations used by the electric utility, such as office buildings, warehouses, garages, machine shops, and recreational buildings that are not an integral part of a generating plant, substation, or control center.
Informational Note:

• This standard addresses safety of workers whose job responsibilities entail interaction with electrical equipment and systems with potential exposure to energized electrical equipment and circuit parts.

• Concepts in this standard are often adapted to other workers whose exposure to electrical hazards is unintentional or not recognized as part of their job responsibilities.

• The highest risk for injury from electrical hazards for other workers involve unintentional contact with overhead power lines and electric shock from machines, tools, and appliances.
Electrical Preventive Maintenance (NFPA 70B)

• is the practice of conducting routine inspections, tests, and the servicing of electrical equipment so that impending troubles can be detected and reduced, or eliminated.

• Electrical equipment is a general term applied to material, fittings, devices, fixtures, and apparatus that are part of, or are used in connection with, an electrical installation.

• This includes the electrical power generating system, substations, distribution systems, utilization equipment, and associated control, protective, and monitoring devices.
Purpose

To reduce hazard to life and property that can result from failure or malfunction of industrial-type electrical systems and equipment.
- Electrical equipment deterioration
- Preventing any unplanned downtime and expensive costs from unanticipated equipment failure.
- Load changes or additions, circuit alterations, improperly set or improperly selected protective devices, and changing voltage conditions.
- Involves the fault diagnosis, routine servicing, functional checks and repairing or replacing of electrical components of a machine and equipment.
- It can be timed i.e. every week, every month or every three months.
WHAT IS AN EFFECTIVE EPM PROGRAM

(1) **Responsible and qualified personnel.**
(2) Survey and analysis of electrical equipment and systems to determine maintenance requirements and priorities.
(3) Programmed routine inspections and suitable tests.
(4) Accurate analysis of inspection and test reports so that proper corrective measures can be prescribed.
(5) Performance of necessary work.
(6) Complete, but concise records.
Survey and analysis should cover equipment and systems that have been previously determined to be essential in accordance with a priority plan.

- All electrical equipment -- motors, transformers, circuit breakers, controls and should be a thorough inspection and evaluation.
- Determining physical condition, the survey should determine if the equipment is operating within its rating.
- In the course of the survey, it is imperative that the condition of electrical protective devices be checked. Such devices include fuses, circuit breakers, protective relays, and motor overload relays.
- These devices are the safety valves of an electrical system. They should be in proper operating condition to ensure safety of personnel, protection of equipment, and reduction of economic loss.
After the survey has been completed, data should be evaluated to determine equipment condition. Equipment condition will reveal repair work to be done, as well as the nature and frequency of required inspections and tests.

3334

Inspection and testing procedures should be carefully tailored to requirements. In some plants, regularly scheduled tests will call for scheduled outages of production or process equipment.

3350.

Analysis of inspection and test reports should be followed by implementation of appropriate corrective measures.

3360.

Records should be accurate, and contain all vital information.
“A **reliable** plant, is cost effective plant, is a safe plant”

Ron Moore
Prevention is Better than Cure
REGISTERED MASTER ELECTRICIAN

MAINTENANCE

PREVENTIVE MAINTENANCE

CORRECTIVE MAINTENANCE

TIME BASED

FAILURE FINDING

CONDITION BASED

PREDICTIVE

RISK BASED

DEFERRED

EMERGENCY
Preventive Maintenance

- Before a failure has occurred

Corrective Maintenance

- After a failure has occurred
Benefits of Preventive maintenance

- Reduce number of equipment failure
- Reduce severity of failures
- Reduce loss of production
- Reduce repair costs
- Improved safety
• PLANNING & SCHEDULING
• IDENTIFY THE ISSUE & ROOT CAUSE OF EQUIPMENT FAILURE

• IMPROVE
• FINE TUNE AND FIX
• CONTINUOUS IMPROVEMENT

• PERFORM
• FIX THE PROBLEM
• APPLY COUNTER MEASURES TO FIX ROOT CAUSE

• MONITOR
• ASSESS IF A PROBLEM IS FIXED
• COMPARE THE RESULTS

PLAN

DO

CHECK

ACT

21
Types of maintenance

• **2a Periodic maintenance (Time based maintenance - TBM)**
  Time based maintenance consists of periodically inspecting, servicing and cleaning equipment and replacing parts to prevent sudden failure and process problems.
• 2b Predictive maintenance

This is a method in which the service life of important part is predicted based on inspection or diagnosis, in order to use the parts to the limit of their service life.
THERMOGRAPHY INSPECTION REPORT

FILE NUMBER: 2018-U5-480VMCC-COOLING TOWER FAN MOTOR 5A-001

EQUIPMENT: COOLING TOWER FAN MOTOR 5A CONTROL PANEL

IMAGE DATE: 10/17/18

LOCATION: US 480V MCC

PARTICULAR: TERMINAL CONTACT OF MAGNETIC CONTACTOR PHASE B, SEC. SIDE

EMISSIVITY: 0.95

CAMERA MODEL: FLIR T340

<table>
<thead>
<tr>
<th>LABEL</th>
<th>VALUE, °C</th>
<th>ΔT. °C</th>
<th>NETA STANDARD</th>
<th>CURRENT, A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OS</td>
<td>OA</td>
<td>OUTDOOR</td>
<td>INDOOR</td>
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<tr>
<td>Bx1: max(phase A, secondary side)</td>
<td>53.9</td>
<td>0.0</td>
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<td>Bx2: max(phase B, secondary side)</td>
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<td>8.1</td>
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<td>54.2</td>
<td>0.3</td>
<td></td>
<td>MINOR</td>
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</table>

FAULT DESCRIPTION: HOTSPOT

ANALYSIS:
HOTSPOT WAS IDENTIFIED ON TERMINAL CONTACT OF PHASE B, SECONDARY SIDE. PROBABLY LOOSENED BOLT DUE TO ELECTRICAL STRESS AND VIBRATION.

RECOMMENDATION:
SCHEDULE SHUT-OFF OF THE EQUIPMENT ON OPPORTUNITY TIME AND THOROUGHLY CHECK, INSPECT AND RETIGHTENED BOLT OF THE CONTACT TERMINAL CONNECTION (Please include the adjacent terminals). RE-SCAN AFTER CORRECTION.

THERMAL IMAGE

DIGITAL IMAGE
Guidelines from Maintenance Testing Specifications for Electrical Power Distribution Equipment and System

<table>
<thead>
<tr>
<th>Severity</th>
<th>Temperature Difference (ΔT), Over Similar, (OS)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor</td>
<td>1 to 3 °C</td>
<td>Indicate possible deficiency and warrant investigation</td>
</tr>
<tr>
<td>Semi Critical</td>
<td>4 to 15 °C</td>
<td>Indicate deficiency; REPAIR AS TIME PERMITS</td>
</tr>
<tr>
<td>Critical</td>
<td>16 °C and above</td>
<td>Indicate major deficiency; REPAIR IMMEDIATELY</td>
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</table>
THERMOGRAPHY INSPECTION REPORT

FILE NUMBER: 2018-U6-480VMCC-COOLING TOWER FAN MOTOR 6C-001

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>IMAGE DATE</th>
<th>LOCATION:</th>
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</thead>
<tbody>
<tr>
<td>COOLING TOWER FAN MOTOR 6C</td>
<td>10/29/18</td>
<td>U6 480V MCC</td>
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<tr>
<td>CONTROL PANEL</td>
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</table>

<table>
<thead>
<tr>
<th>PARTICULAR</th>
<th>EMISSIVITY</th>
<th>CAMERA MODEL:</th>
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</thead>
<tbody>
<tr>
<td>TERMINAL CONTACT OF MAGNETIC</td>
<td>0.95</td>
<td>FLIR T340</td>
</tr>
<tr>
<td>CONTACTOR PHASE B, SEC. SIDE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LABEL</th>
<th>VALUE, °C</th>
<th>ΔT. °C</th>
<th>NETA STANDARD</th>
<th>CURRENT, A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bx1: max(phase A, secondary side)</td>
<td>54.0</td>
<td>0.0</td>
<td>OUTDOOR</td>
<td>AS FOUND</td>
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<tr>
<td>Bx2: max(phase B, secondary side)</td>
<td>64.5</td>
<td>10.5</td>
<td>INDOOR</td>
<td>NA</td>
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<tr>
<td>Bx3: max(phase C, secondary side)</td>
<td>55.7</td>
<td>1.7</td>
<td>MINOR</td>
<td>NA</td>
</tr>
</tbody>
</table>

FAULT DESCRIPTION: HOTSPOT

ANALYSIS:
HOTSPOT WAS IDENTIFIED ON TERMINAL CONTACT OF PHASE B, SECONDARY SIDE. PROBABLY LOOSENED BOLT DUE TO ELECTRICAL STRESS AND VIBRATION.

RECOMMENDATION:
SCHEDULE SHUT-OFF OF THE EQUIPMENT ON OPPORTUNITY TIME AND THOROUGHLY CHECK, INSPECT AND RE-TIGHTENED BOLT OF THE CONTACT TERMINAL CONNECTION (Please include the adjacent terminals). RE-SCAN AFTER CORRECTION.

THERMAL IMAGE

DIGITAL IMAGE
# Guidelines from Maintenance Testing Specifications for Electrical Power Distribution Equipment and System

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<td>4 to 15 °C</td>
<td>Indicate deficiency; REPAIR AS TIME PERMITS</td>
</tr>
<tr>
<td>Critical</td>
<td>16 °C and above</td>
<td>Indicate major deficiency; REPAIR IMMEDIATELY</td>
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<th>EMISSIVITY</th>
<th>CAMERA MODEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR CIRCUIT BREAKER OF 52CC6 480V COMMON MCC, CB CONTROL PANEL</td>
<td>7/4/2018</td>
<td>PLT C 480V MCC</td>
<td>TERMINAL CONTACT OF CIRCUIT BREAKER, INCOMING SIDE</td>
<td>0.95</td>
<td>FLIR T640</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LABEL</th>
<th>VALUE, ºC</th>
<th>∆T, ºC</th>
<th>NETA STANDARD</th>
<th>CURRENT, A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bx1: max(phase A, incoming side)</td>
<td>92.7</td>
<td>27.6</td>
<td>CRITICAL</td>
<td>AS FOUND, NA</td>
</tr>
<tr>
<td>Bx2: max(phase B, incoming side)</td>
<td>160.2</td>
<td>95.1</td>
<td>CRITICAL</td>
<td>NA</td>
</tr>
<tr>
<td>Bx3: max(phase C, incoming side)</td>
<td>65.1</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FAULT DESCRIPTION: HOTSPOT

REMARKS:
HOTSPOT WERE IDENTIFIED ON TERMINAL CONTACT OF ACB PHASE A AND B, INCOMING SIDE. ALSO AN UNPLEASANT SMELL OF BURNING INSULATION WAS NOTICE. PROBABLY LOOSENED BOLTS AND CORROSIONS. CONTINUOUS MONITORING IS BEING CONDUCTED.

RECOMMENDATION:
IMMEDIATE SHUT-OFF OF THE BREAKER AND THOROUGHLY CHECK THE TERMINALS, INSPECT, CLEAN SURFACE CONTACTS AND RE-TIGHTENED BOLTS. RE-SCAN AFTER CORRECTION. FOR THE MEANTIME, INSTALL A BLOWER TO THE HOTSPOT AREA TO DISSIPATE THE HIGH TEMPERATURE AND CHANGE-OVER TO 52CC5 ACB.
**Fault Description:** Hotspot

**Remarks:**
Hotspot were identified on terminal contact of ACB Phase A and B, incoming side. Also an unpleasant smell of burning insulation was noticed. Probably loosened bolts and corrosions. Continuous monitoring is being conducted.

**Recommendation:**
Immediate shut-off of the breaker and thoroughly check the terminals, inspect, clean surface contacts and re-tightened bolts. Re-scan after correction. For the meantime, install a blower to the hotspot area to dissipate the high temperature and change-over to 52CC5 ACB.

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**Thermal Image (Phase A)**

**Digital Image (Phase A)**
AIR CIRCUIT BREAKER
480V, 3 PHASE
Preventive Maintenance of Electrical Equipment
ITC- Infrared Thermography Certification is the gold-standard qualification within the thermography industry. ITC certification verifies that a thermographer can:

Operate an infrared camera.

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**Guidelines from Maintenance Testing Specifications for Electrical Power Distribution Equipment and System**

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<td>15 °C and above</td>
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</tr>
</tbody>
</table>

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B.A. Servino  
ITC-L1 CERTIFIED

I.V. Escopete, Jr.  
ITC-LEVEL 2 CERTIFIED
• Electric Motor:

A motor is an electrical machine which converts electrical energy into mechanical energy. When a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force and this is the principle behind motoring action.
Large Motor – 4.16kv – 700hp
Exciter Carbon Brush Assembly
Preventive Maintenance of Electrical Equipment - iiiee Philippines
Overheating
Stator windings – 60 MW
### Certificate of Conformance

#### polyester webbing sling

<table>
<thead>
<tr>
<th>Distinguishing number or mark</th>
<th>Description</th>
<th>Working Load Limit (WLL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>561221</td>
<td>&quot;SUPERLIFT&quot; Polyester Web Sling, 6&quot; x 6Mtrs.</td>
<td>6.00 tons</td>
</tr>
<tr>
<td></td>
<td>Color: Brown</td>
<td></td>
</tr>
<tr>
<td>561223</td>
<td>&quot;SUPERLIFT&quot; Polyester Web Sling, 6&quot; x 6Mtrs.</td>
<td>6.00 tons</td>
</tr>
<tr>
<td></td>
<td>Color: Brown</td>
<td></td>
</tr>
</tbody>
</table>

### Certificate of Conformance

POLYESTER WEBBING SLING TO BS:3481 PART2:1983
POLYESTER ROUND SLING TO BS:6668 PART2:1987
SAFETY FACTOR: 6:1

<table>
<thead>
<tr>
<th>Distinguishing number or mark</th>
<th>Description of gear.</th>
<th>Quantity</th>
<th>Date</th>
<th>Working Load Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPERLIFT 65 2486</td>
<td>POLYESTER WEBBING SLING</td>
<td></td>
<td>4,000 KG</td>
<td>STRAIGHT PULL</td>
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<tr>
<td></td>
<td>WIDTH 4&quot;</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>TYPE DEE</td>
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<td></td>
<td>COLOR GREY</td>
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<tr>
<td></td>
<td>LENGTH 3M</td>
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<tr>
<td></td>
<td>SAFETY FACTOR 6:1</td>
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<tr>
<td></td>
<td>1 PC</td>
<td></td>
<td>2016-11-8</td>
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</tr>
</tbody>
</table>

Preventive Maintenance of Electrical Equipment iieecamarines clfjr
12tons - Rotor
Preventive Maintenance of Electrical Equipment
Pull out of rotor – using web sling
Preventive Maintenance of Electrical Equipment
Equipment safety
Substation - outdoor
Equipment are installed in substations:

- Transformer
- Circuit breaker
- Lightning Arrester
- Air Break (AB) switches / Isolator
- Insulator
- Busbar
- Capacitor Bank
- Earthing
- Distribution panel board
Preventive Maintenance of Electrical Equipment (R. A. S. R. M.)
Permit to work with associated electrical permit
Lockout / Tagout procedures are designed to isolate or shut off machines and equipment from their power sources before employees perform any servicing or maintenance work.

**Definition:**

**Lockout** is the placement of a lockout device on an energy isolation apparatus (circuit breaker, slide gate, line valve, disconnect switch, etc.) to ensure that the energy isolating device and equipment being controlled cannot be operated until the lockout device is removed. A lockout device utilizes a positive means such as a lock (key or combination type) to hold an energy isolating device in a safe position and prevent the energization of a machine or equipment. The lockout device must be substantial enough to prevent removal without use of excessive force or unusual techniques.

**Tagout** is the placement of a tagout device (a tag or other prominent warning device and a means of attachment) on an energy isolation device to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

**Energy-isolating device**

Any mechanical device that physically prevents the transmission or release of energy. These include, but are not limited to, manually operated electrical circuit breakers, disconnected switches, line valves and blocks.

Employees performing maintenance or service on machines or equipment shall observe the following procedures:

- Lockout / Tagout of energy isolating devices shall be performed whenever maintenance or servicing is done on machines or equipment. This shall be done by employees who have received proper training on lockout/tagout procedures from Environmental Health and Safety.
- Employees observing a machine or piece of equipment which is locked or tagged out shall not attempt to start, energize or use that machine or equipment.
- Lockout and Tagout devices shall indicate the identity of the employee who attached the devices.
- Lockout and Tagout devices shall be standardized within the facility.
- If an energy isolating device is not capable of being locked out, a tagout system shall be used.
- Tagout devices shall include warning statements such as “DO NOT ENERGIZE!” or “DO NOT OPERATE!”
- Whenever replacement, major repair, renovation or modification of equipment is performed, energy isolating devices for such machines or equipment shall be designed to accept a lockout device.

Retraining shall be provided for all authorized and affected employees whenever there is a change in their job assignments, a change in machines, equipment or processes that present a new hazard, or when there is a change in the energy control procedures.

Sources for More Information:

- ANSI Z244.1-1982, Personal Protection Lockout / Tagout of Energy Sources.
- American National Standards Institute (ANSI) 25 W. 43rd St., 4th Floor, New York, NY 10036 (212) 642-4800

worldjournals2007.com
It’s true...

Y O L O
You Only Live Once
So always...

L O T O
Lock Out Tag Out
Preventive Maintenance of Electrical Equipment
Preventive Maintenance of Electrical Equipment features extensive damage due to failure in maintenance procedures.
REGISTERED MASTER ELECTRICIAN AFFAIRS COMMITTEE

Preventive Maintenance of Electrical Equipment
Preventive Maintenance of Electrical Equipment
Indoor Substation
Preventive Maintenance of Electrical Equipment

iieecamarines clfjr
Preventive Maintenance of Electrical Equipment iieecamarines clfr
Circuit breaker
# Possible Preventive Maintenance Schedule for Electrical Apparatus in a Petrochemical Process Plant

<table>
<thead>
<tr>
<th>Electrical Apparatus</th>
<th>Preventive Maintenance</th>
<th>Weekly</th>
<th>Monthly</th>
<th>Annually</th>
<th>Every 2 Years</th>
<th>Every 3 Years</th>
<th>Change Only If Required</th>
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<tbody>
<tr>
<td>Battery Systems</td>
<td>Check Voltage</td>
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<tr>
<td></td>
<td>Check Voltage Alarm</td>
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<td>Specific Gravity and Plates</td>
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<td>Emergency Transfer Schemes</td>
<td>Standby Generators—run up</td>
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<td>Complete Transfer</td>
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<td>Main Circuit Breakers</td>
<td>Operational Check</td>
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<td>Oil Inspection</td>
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<td>Main Substation Transformers</td>
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<td>Motors</td>
<td>Bearings</td>
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<td>Ventilation</td>
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<tr>
<td>Protection</td>
<td>Cleaned and Checked for Calibration</td>
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<tr>
<td>Substation High Voltage</td>
<td>Incoming Lines—Dirty Atmos</td>
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<tr>
<td></td>
<td>Incoming Lines—Clean Areas</td>
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<tr>
<td>Unit Substations</td>
<td>Ground Indicators</td>
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</tr>
<tr>
<td></td>
<td>Sump Pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Housekeeping</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temperature &amp; Load Check</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil Inspection—Transformers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* asterisk indicates mandatory maintenance.
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Preventive Maintenance of Electrical Equipment
Preventive Maintenance of Electrical Equipment
3. Corrective maintenance (1957)
   It improves equipment and its components so that preventive maintenance can be carried out reliably. Equipment with design weakness must be redesigned to improve reliability or improving maintainability.

OVERHAULING
1. Replacement of parts. 2. Testing of electrical equipment 3. Calibration of protection relays 4. Replacement of new motors (as spare)
Online monitoring system

Preventive Maintenance of Electrical Equipment iieecamarines clfjr
**Online Monitoring System**

### Stator Wind Temperature

<table>
<thead>
<tr>
<th>GEN/RTMP</th>
<th>SLT2(2)</th>
<th>T/G OIL TEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>58.72°C</td>
<td>64.16°C</td>
<td>TE105/OIL IN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>54.38°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SLT1(1)</th>
<th>SLT1(3)</th>
<th>TE106/OIL OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>54.49°C</td>
<td>64.86°C</td>
<td>45.66°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SLT19(5)</th>
<th>SLT2(4)</th>
<th>TE107/TURBRG1-F</th>
</tr>
</thead>
<tbody>
<tr>
<td>56.46°C</td>
<td>56.73°C</td>
<td>54.07°C</td>
</tr>
</tbody>
</table>

### Cooler Temperature

<table>
<thead>
<tr>
<th>CLR2(14)</th>
<th>CLR2(18)</th>
<th>T/G OIL TEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>48.21°C</td>
<td>43.46°C</td>
<td>TE111/TRTBRG17-F</td>
</tr>
<tr>
<td></td>
<td></td>
<td>54.78°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLR3(15)</th>
<th>CLR3(19)</th>
<th>TE112/TURBRG12-R</th>
</tr>
</thead>
<tbody>
<tr>
<td>48.63°C</td>
<td>44.45°C</td>
<td>55.73°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLR1(17)</th>
<th>CLR4(20)</th>
<th>TE101/TRTBRG-FL</th>
</tr>
</thead>
<tbody>
<tr>
<td>43.19°C</td>
<td>44.16°C</td>
<td>51.09°C</td>
</tr>
</tbody>
</table>

### TE108/TURBRG2-R Temperature

- 54.22°C

### TE109/GENBRG3-F Temperature

- 50.93°C

### TE110/GENBRG4-R Temperature

- 51.17°C

---

**Preventive Maintenance of Electrical Equipment**

**IEEE Camarines CLFJR**

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**IEEE Camarines CLFJR**

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**IEEE Camarines CLFJR**
Preventive Maintenance of Electrical Equipment
How to measure insulation resistance
Winding insulation resistance

• If the motor is not put into operation immediately upon arrival, it is important to protect it against external factors like moisture, high temperature and impurities in order to avoid damage to the insulation.

• Before the motor is put into operation after a long period of storage, you have to measure the winding insulation resistance.
Safety Tips:
During the measurement and immediately afterwards, some of the terminals carry dangerous voltages and MUST NOT BE TOUCHED.

*Ground insulation test of a motor*
Three points are worth mentioning in this connection:
Insulation resistance, Measurement and Checking.

1. Insulation resistance

✓ The minimum insulation resistance of new, cleaned or repaired windings with respect to ground is **10 Megohm or more**.

✓ The minimum insulation resistance, \( R \), is calculated by multiplying the **rated voltage** \( U_n \), with the **constant factor** 0.5 Megohm/kV.
2. Measurement

• Minimum insulation resistance of the winding to ground is measured with 500 V DC. The winding temperature should be 25°C ± 15°C.

• Maximum insulation resistance should be measured with 500 V DC with the windings at a operating temperature of 80 – 120°C depending on the motor type and efficiency.
3. Checking

- If the insulation resistance of a new, cleaned or repaired motor that has been stored for some time is less than 10 megohm, the reason might be that the windings are humid and need to be dried.

- If the motor has been operating for a long period of time, the minimum insulation resistance may drop to a critical level. As long as the measured value does not fall below the calculated value of minimum insulation resistance, the motor can continue to run.
Ambient temperature;

- Ambient temperatures below –30°C can require special bearing lubricant and material requirements.
- Ambient temperatures above 40°C may result in the allowable motor temperature rise to be lowered, which effectively de-rates the motor output.
• 1. **Breakdown maintenance** - It means that people/management waits until equipment fails and repair it. Such a thing could be used when the equipment failure does not significantly affect the operation or production or generate any significant loss other than repair cost.
The first W is What.
The second W is Where.
The third W is When.
The forth W is Who.
Then it is about How.
The last W is Why.

1. Manpower
2. Machinery
3. Materials
4. Method
5. Mother-nature
6. Measurement

1. Physical Evidence
2. Personnel
3. Place
4. Product (Service)
5. Price
6. Promotion
7. Process
8. Productivity & quality
Switch gear/MCC & Transformer
Fishbone Diagram - Causes of Low-Quality Output

- **Working Conditions**
  - Noise
  - Humidity
  - Temperature
  - Season
- **Raw Materials**
  - Moisture Contents
  - Workplace
  - Strength
  - Storage Conditions
  - Draught
  - Temperature
  - Humidity
- **Management**
  - Delivery Times
  - Shelf Life
  - Process Providing
  - Impurities
  - Basic & Auxiliary Materials
  - Mechanical Properties
  - Intermediates
  - Equipment
- **Technology**
  - Availability Tool
  - Availability of Documents
  - Machine Wear
  - Machine Type
  - Unbalance
  - Deformation
- **Machine**
  - Operating Conditions
  - Product Qualification
  - Part Control
  - Method
  - Operation
  - Tool Set
- **Workers**
  - Quality of Parts Coming from Previous Operations
  - Health
  - Ailment
  - Concentration
  - Behavior at Work
  - Education
  - Abilities
  - Work Experience

Poor Quality Product
Air circuit breaker
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### Breakdown Process

**Operator**
- Initiate EWO
- Perform & record basic condition checks
- Enter symptoms
- Record 5W and 1H to help diagnose

**Engineer**
- Perform diagnosis and make repair
- Record fault, hours spent and parts used
- Confirm area clear of tools
- Hand back to Operator

**Analysis & Action**
- Root Cause Analysis
- Identify actions to prevent recurrence

**Follow-up**
- Check actions and monitor recurrence
- Assess benefits of improvements made

---

**COMMUNICATION**

**PRODUCTIVITY**

**TRANSPARENCY**
Figure 1 — If the output pulses from an IGBT-based drive travel a distance to the motor, it can reach an amplitude destructive to the motor insulation. The burned section in the photo was caused by such a reflected wave.
### RULE OF THUMB IS 10 MEGOHMS or more

<table>
<thead>
<tr>
<th>Insulation resistance value (Mega-ohms)</th>
<th>Insulation level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 mega ohms or less</td>
<td>Bad</td>
</tr>
<tr>
<td>2-5</td>
<td>Critical</td>
</tr>
<tr>
<td>5-10</td>
<td>Abnormal</td>
</tr>
<tr>
<td>10-50</td>
<td>Good</td>
</tr>
<tr>
<td>50-100</td>
<td>Very good</td>
</tr>
<tr>
<td>100 Mega-ohm or more</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
TABLE 100.1

Insulation Test Voltages and Analysis of Test Results

<table>
<thead>
<tr>
<th>Rated Voltage of Equipment</th>
<th>Recommended Test Voltage*</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>500</td>
</tr>
<tr>
<td>600</td>
<td>1,000</td>
</tr>
<tr>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>2,500</td>
<td>1,000</td>
</tr>
<tr>
<td>5,000</td>
<td>2,500</td>
</tr>
<tr>
<td>8,000</td>
<td>2,500</td>
</tr>
<tr>
<td>15,000</td>
<td>2,500</td>
</tr>
<tr>
<td>25,000</td>
<td>5,000</td>
</tr>
<tr>
<td>34,500 and above</td>
<td>5,000</td>
</tr>
</tbody>
</table>

* These values should only be utilized in the absence of manufacturer guidelines or other standards that are specific to the equipment type being tested.

Evaluation of Results:

The main value of insulation resistance testing lies in the charting of data recorded from periodic tests. For the data to be useful, the tests should be conducted in a similar manner each time. All test data should be corrected for temperature using Table 100.14.
### Class Insulation

<table>
<thead>
<tr>
<th>Insulation System</th>
<th>Temperature Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A Class 105</td>
<td>105 °C 221 °F</td>
</tr>
<tr>
<td>Class E* Class 120</td>
<td>120 °C 248 °F</td>
</tr>
<tr>
<td>Class B Class 130</td>
<td>130 °C 266 °F</td>
</tr>
<tr>
<td>Class F Class 155</td>
<td>155 °C 311 °F</td>
</tr>
<tr>
<td>Class H Class 180</td>
<td>180 °C 356 °F</td>
</tr>
<tr>
<td>Class N Class 200</td>
<td>200 °C 392 °F</td>
</tr>
<tr>
<td>Class R Class 200</td>
<td>220 °C 428 °F</td>
</tr>
<tr>
<td>Class S Class 240</td>
<td>240 °C 464 °F</td>
</tr>
<tr>
<td>Class C Class over 240</td>
<td>Over 240 °C Over 464 °F</td>
</tr>
</tbody>
</table>

* *Used in European equipment*
GENERATOR BREAKER
use to measure the low resistance of the winding in terms of micro ohms
Testing connections

A megohmmeter usually is equipped with three terminals. The "LINE" (or "L") terminal is the so-called "hot" terminal and is connected to the conductor whose insulation resistance you are measuring. Remember: These tests are performed with the circuit deenergized.

The "EARTH" (or "E") terminal is connected to the other side of the insulation, the ground conductor.

The "GUARD" (or "G") terminal provides a return circuit that bypasses the meter. For example, if you are measuring a circuit having a current that you do not want to include, you connect that part of the circuit to the "GUARD" terminal.
Figs. 2, 3, and 4 show connections for testing three common types of equipment. Fig. 2 shows a connection for testing a transformer bushing, without measuring the surface leakage. Only the current through the insulation is measured, since any surface current will be returned on the "GUARD" lead.

Various insulation tests
IR Testing (HV-Earth)

LV1  HV1
LV2  HV2
LV3  HV3

Megger

IR Testing (HV-LV)

LV1  HV1
LV2  HV2
LV3  HV3

Megger
Temporary short for the duration of the test

Test 1
Primary Winding to core

Test 2
Secondary winding to core

Primary Winding

Secondary Winding

MΩ 500V
Winding to ground
Fig. 3

- Motor
- Starter
- Red/earth lead
- Main switch
- Insulation tester
- Source
Preventive Maintenance of Electrical Equipment
Preventive Maintenance of Electrical Equipment

IR Testing between All Phase To Ground

IR Testing between Each Phase To Earth

Delta connection

Star connection
<table>
<thead>
<tr>
<th>Insulation Condition</th>
<th>60/30-sec Ratio</th>
<th>10/1-min Ratio (Polarization Index)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangerous</td>
<td>-</td>
<td>Less than 1</td>
</tr>
<tr>
<td>Questionable</td>
<td>1.0 to 1.25</td>
<td>1.0 to 2*</td>
</tr>
<tr>
<td>Good</td>
<td>1.4 to 1.6</td>
<td>2 to 4</td>
</tr>
<tr>
<td>Excellent</td>
<td>Above 1.6**</td>
<td>Above 4**</td>
</tr>
</tbody>
</table>

**Table 2.** Listing of conditions of insulation as indicated by Dielectric Absorption Ratios. These values must be considered tentative and relative, subject to experience with the time-resistance method over a period of time.
ELECTRICIAN

(i,-læk-ˈtrish-ən) n. 1: a well-grounded person 2: avoids at all times 3: able to fix about anything with a , a roll of and a few 4: keeps up with "current" events 5: someone who has found an outlet for their talents 6: actually knows what means

Preventive Maintenance of Electrical Equipmentبهامارینس إلى

Safe Electricity