
04/19/2017

REGISTERED MASTER ELECTRICIAN AFFAIRS COMMITTEE & ELECTRICIAN'S ACADEMY

- presents -

BSIT - ELECTRICAL

MASTER OF BUSINESS ADMINISTRATION

REGISTERED MASTER ELECTRICIAN

CERTIFIED PLANT MECHANIC

TESDA EIM, HEAVY EQUIPMENT OPERATOR, SCAFFOLDER

DOLE-ACCREDITED SAFETY PRACTITIONER.. OSH CONSULTANT

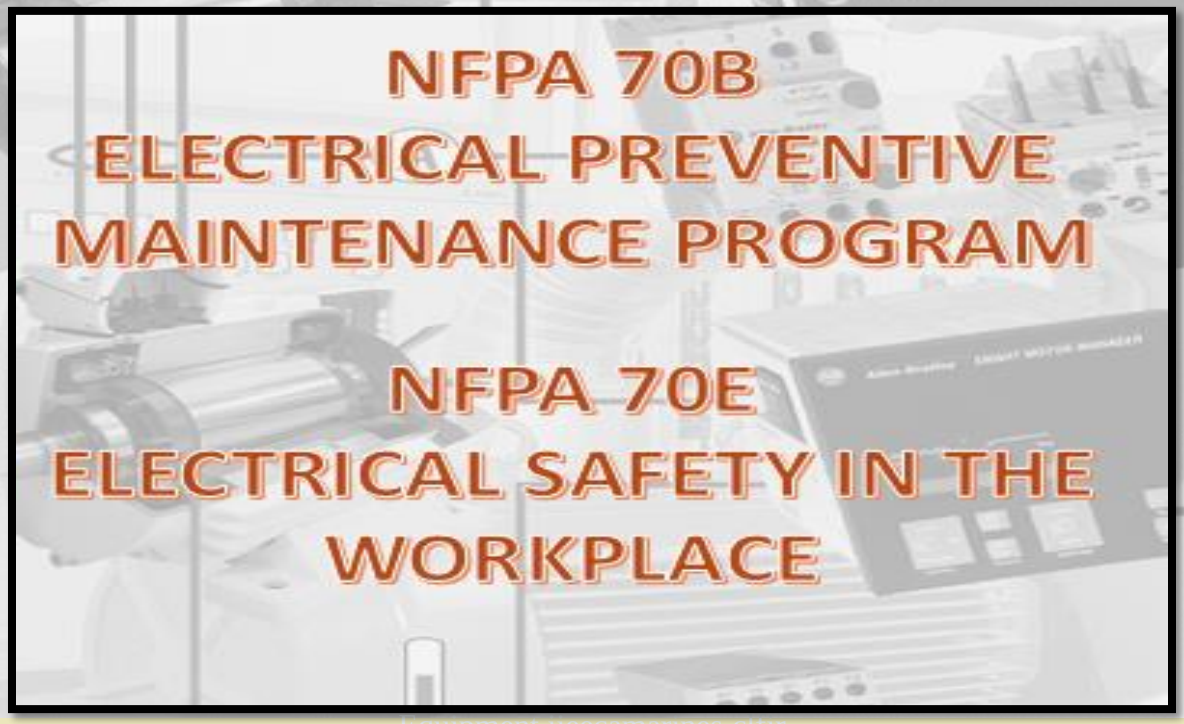
ASEAN TECHNICIAN AT501

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 - Recommended Practice for Electrical Equipment Maintenance Scope

- 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.

NFPA 70E® - Standard for Electrical Safety in the Workplace® Scope

- 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.

Why EPM

- 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.

3332.

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

TYPES OF MAINTENANCE

- MAINTENANCE
  - PREVENTIVE MAINTENANCE
    - TIME BASED
    - FAILURE FINDING
    - CONDITION BASED
    - PREDICTIVE
    - RISK BASED
  - CORRECTIVE MAINTENANCE
    - DEFERRED
    - EMERGENCY

PREVENTIVE MAINTENANCE VS CORRECTIVE MAINTENANCE

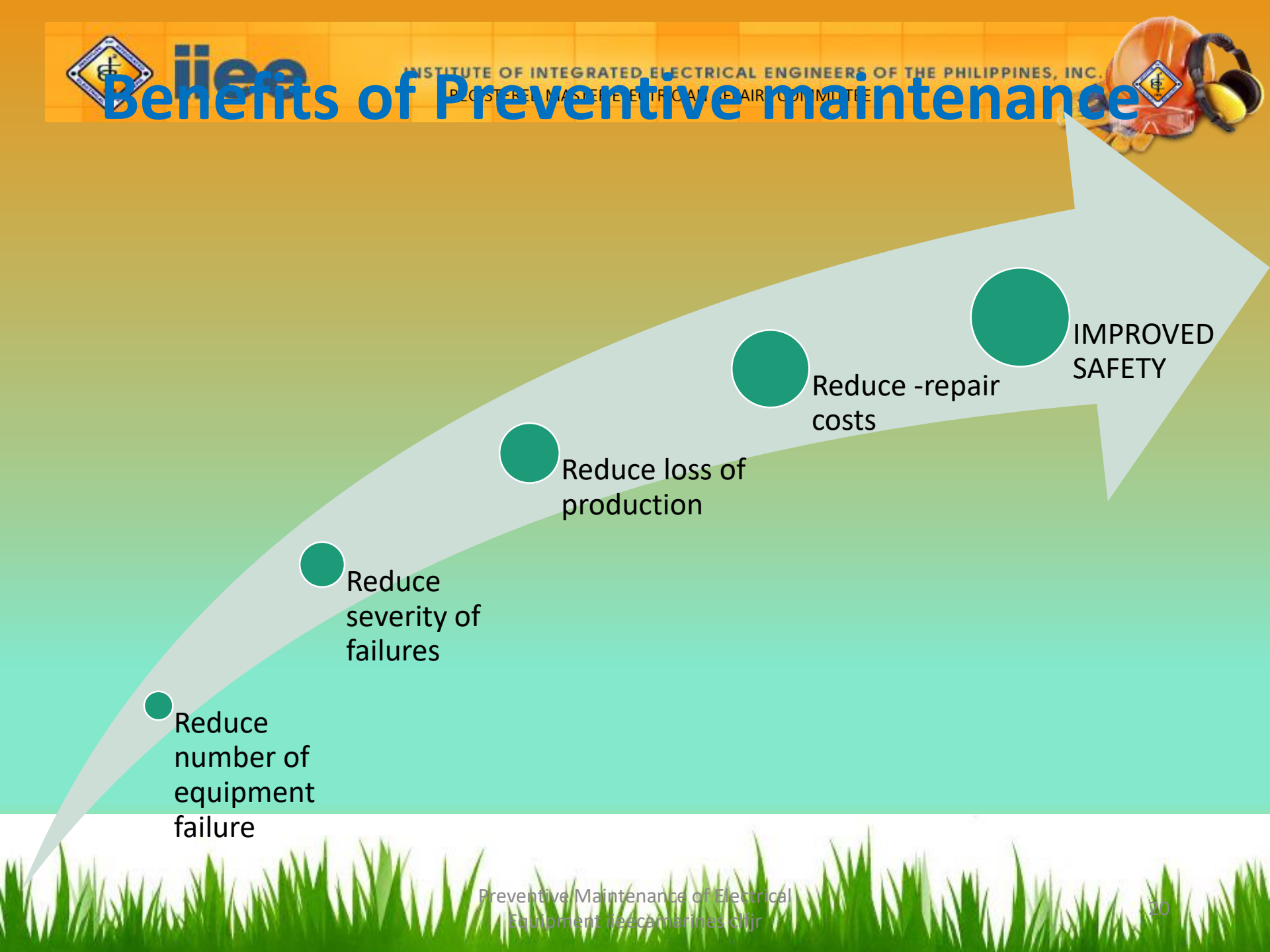
Preventive Maintenance

- Before a failure has occurred

Corrective Maintenance

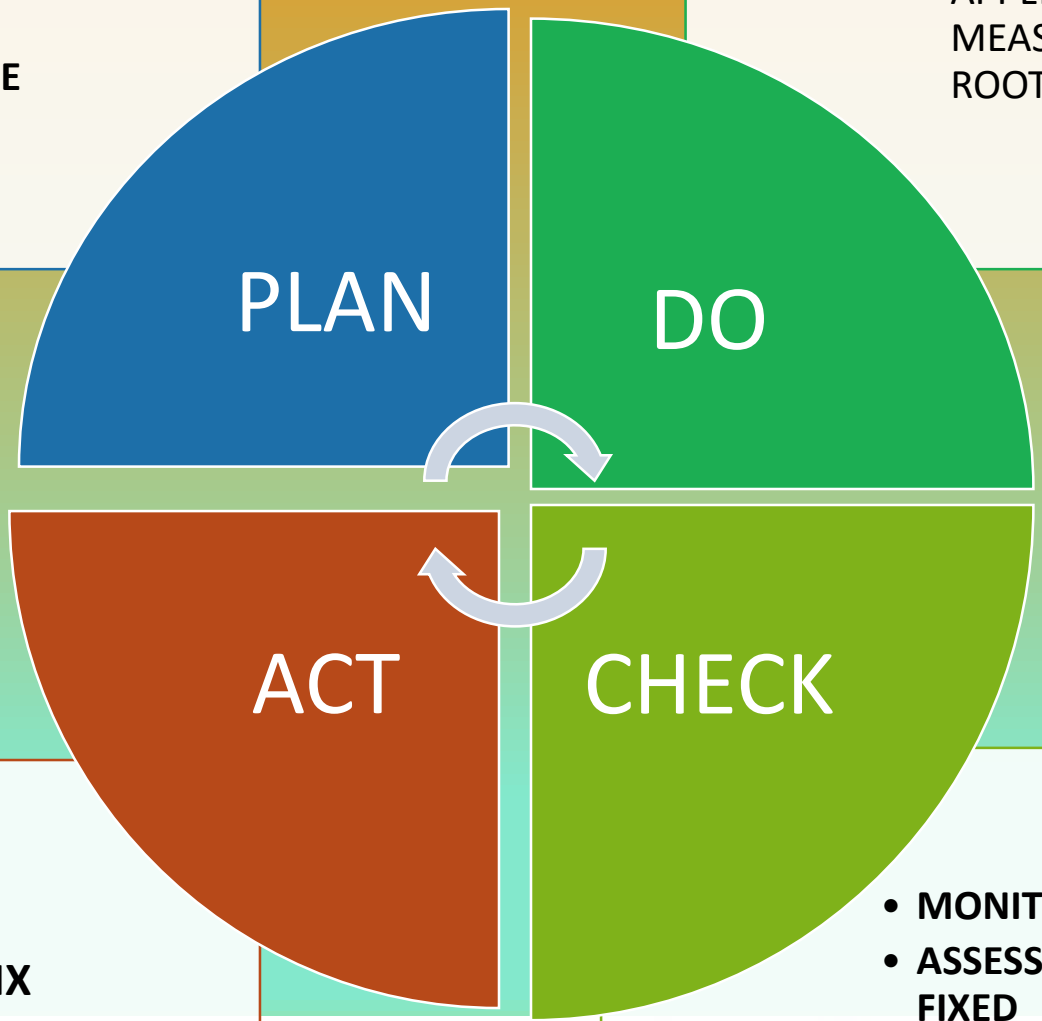
- After a failure has occurred

Benefits of Preventive maintenance



- **PLANNING & SCHEDULING**
- **IDENTIFY THE ISSUE & ROOT CAUSE OF EQUIPMENT FAILURE**

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



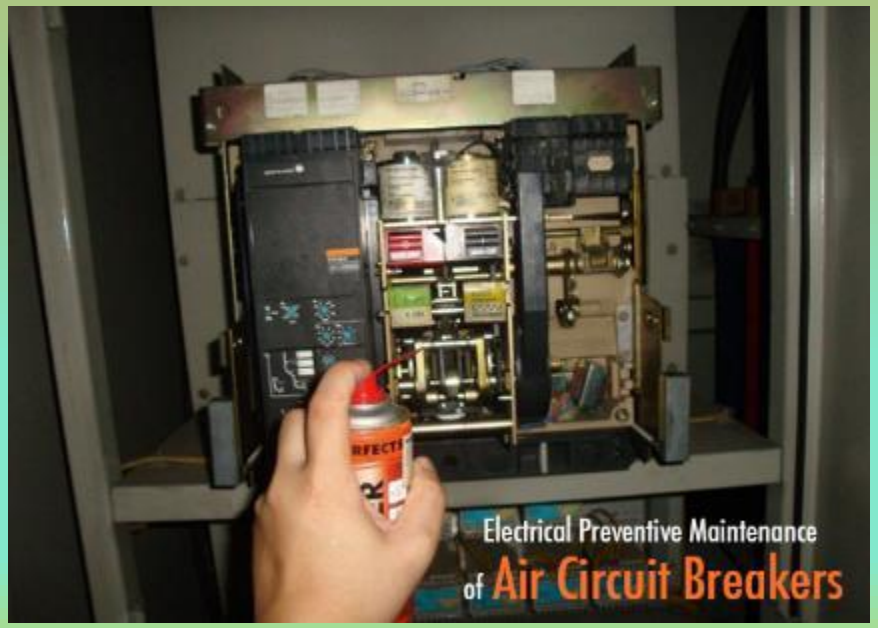
- **IMPROVE**
- **FINE TUNE AND FIX**
- **CONTINUOUS IMPROVEMENT**

- **MONITOR**
- **ASSESS IF A PROBLEM IS FIXED**
- **COMPARE THE RESULTS**

Types of maintenance

PM

- 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.



PM

- 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:	U5 480V MCC
PARTICULAR	TERMINAL CONTACT OF MAGNETIC CONTACTOR PHASE B, SEC. SIDE	EMISSIVITY	0.95	CAMERA MODEL:	FLIR T340

LABEL	VALUE, °C	ΔT. °C		NETA STANDARD		CURRENT, A	
		OS	OA	OUTDOOR	INDOOR	AS FOUND	% UNBALANCED
Bx1: max(phase A, secondary side)	53.9	0.0					
Bx2: max(phase B, secondary side)	62.0	8.1			SEMI-CRITICAL	NA	
Bx3: max(phase C, secondary side)	54.2	0.3			MINOR	NA	

FAULT DESCRIPTION: HOTSPOT

ANALYSIS:

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

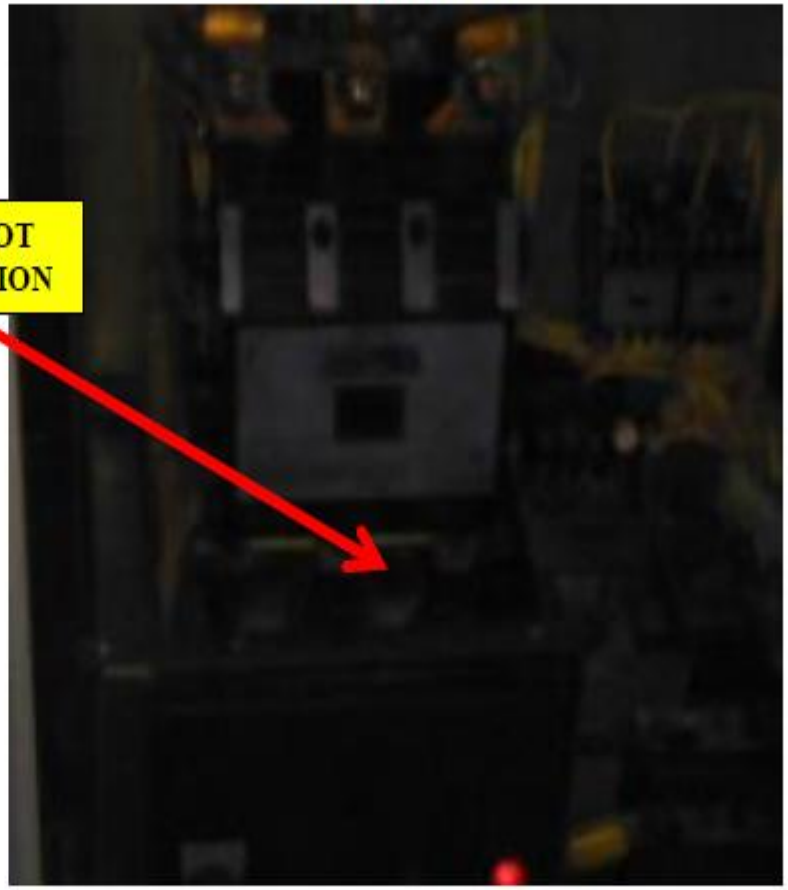
RECOMMENDATION:

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

THERMAL IMAGE

DIGITAL IMAGE



Guidelines from Maintenance Testing Specifications for Electrical Power Distribution Equipment and System		
Severity	**Temperature Diffrence (ΔT), Over Similar,(OS)**	**Remarks**
Minor	1 to 3 °C	*Indicate possible deficiency and warrant investigation*
Semi Critical	4 to 15 °C	*Indicate deficiency; REPAIR AS TIME PERMITS*
Critical	16 °C and above	*Indicate major deficiency; REPAIR IMMEDIATELY*

THERMOGRAPHY INSPECTION REPORT

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

EQUIPMENT	COOLING TOWER FAN MOTOR 6C CONTROL PANEL	IMAGE DATE	10/29/18	LOCATION:	U6 480V MCC
PARTICULAR	TERMINAL CONTACT OF MAGNETIC CONTACTOR PHASE B, SEC. SIDE	EMISSIVITY	0.95	CAMERA MODEL:	FLIR T340

LABEL	VALUE, °C	ΔT. °C		NETA STANDARD		CURRENT, A	
		OS	OA	OUTDOOR	INDOOR	AS FOUND	% UNBALANCED
Bx1: max(phase A, secondary side)	54.0	0.0					
Bx2: max(phase B, secondary side)	64.5	10.5			SEMI-CRITICAL	NA	
Bx3: max(phase C, secondary side)	55.7	1.7			MINOR	NA	

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:

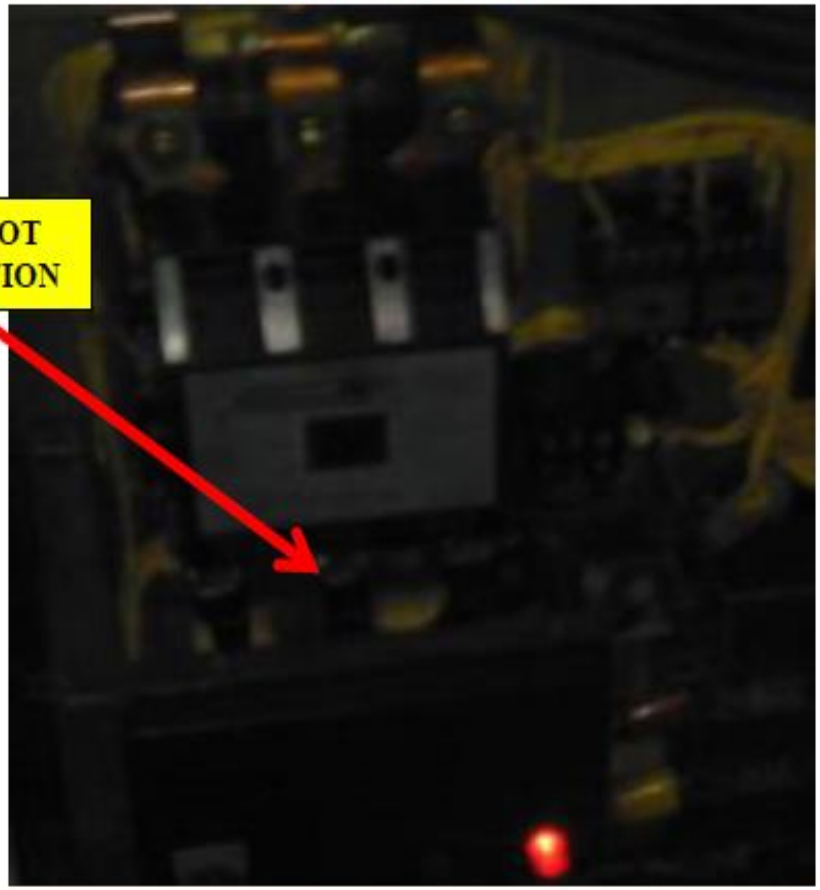
SCHEDULE SHUT-OFF OF THE EQUIPMENT ON OPPORTUNITY TIME AND THOROUGHLY CHECK, INSPECT AND RE-TIGHTENED BOLT OF THE CONTACT TERMINAL CONNECTION (Please include the adjacent terminals). RE-SCAN AFTER CORRECTION.

THERMAL IMAGE

DIGITAL IMAGE

THERMAL IMAGE

DIGITAL IMAGE



Guidelines from Maintenance Testing Specifications for Electrical Power Distribution Equipment and System		
Severity	**Temperature Diffrence (ΔT), Over Similar,(OS)**	**Remarks**
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Semi Critical	4 to 15 °C	*Indicate deficiency; REPAIR AS TIME PERMITS*
Critical	16 °C and above	*Indicate major deficiency; REPAIR IMMEDIATELY*

THERMOGRAPHY INSPECTION REPORT

FILE NUMBER:

EQUIPMENT	AIR CIRCUIT BREAKER OF 52CC6 480V COMMON MCC , CB CONTROL PANEL	IMAGE DATE	7/4/2018	LOCATION:	PLT C 480V MCC
PARTICULAR	TERMINAL CONTACT OF CIRCUIT BREAKER, INCOMING SIDE	EMISSIVITY	0.95	CAMERA MODEL:	FLIR T640

LABEL	VALUE, °C	ΔT. °C		NETA STANDARD		CURRENT, A	
		OS	OA	OUTDOOR	INDOOR	AS FOUND	% UNBALANCED
Bx1: max(phase A, incoming side)	92.7	27.6			CRITICAL	NA	
Bx2: max(phase B, incoming side)	160.2	95.1			CRITICAL	NA	
Bx3: max(phase C, incoming side)	65.1	0.0					

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.

THERMAL IMAGE (Phase A)	DIGITAL IMAGE (Phase A)

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:

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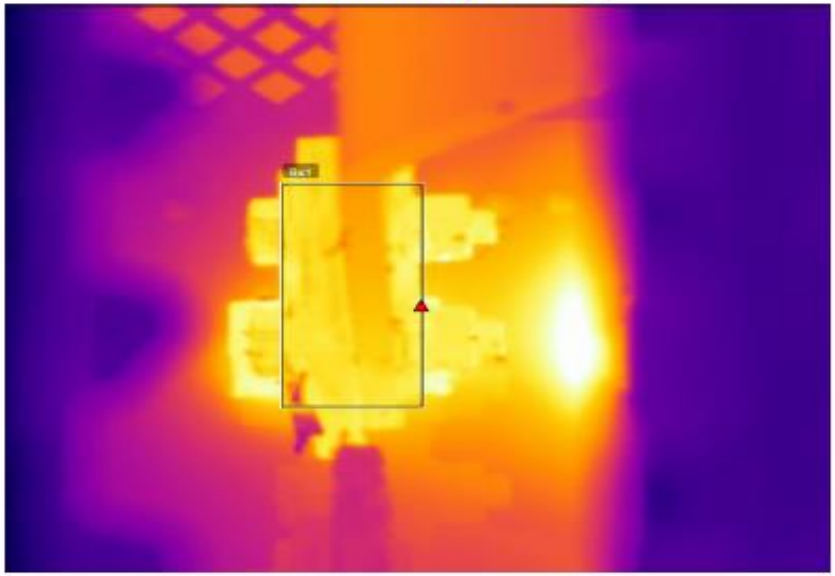
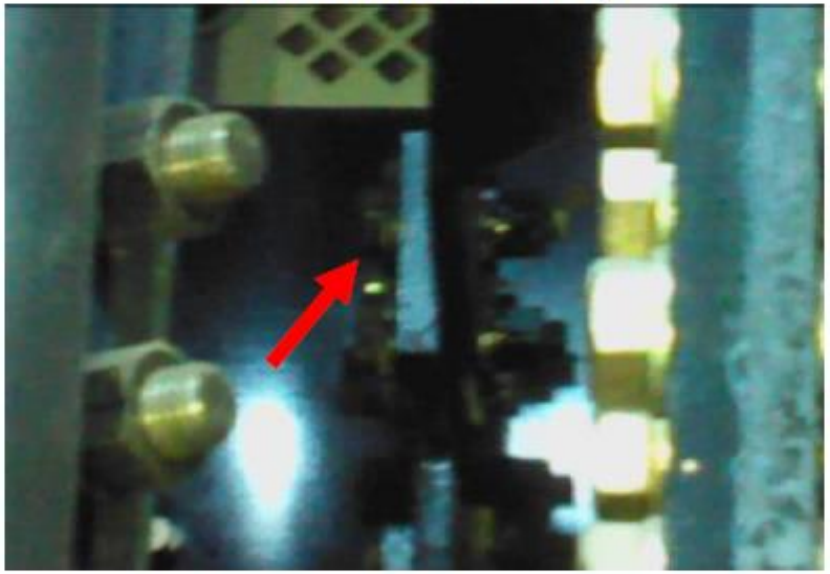
THERMAL IMAGE (Phase A)

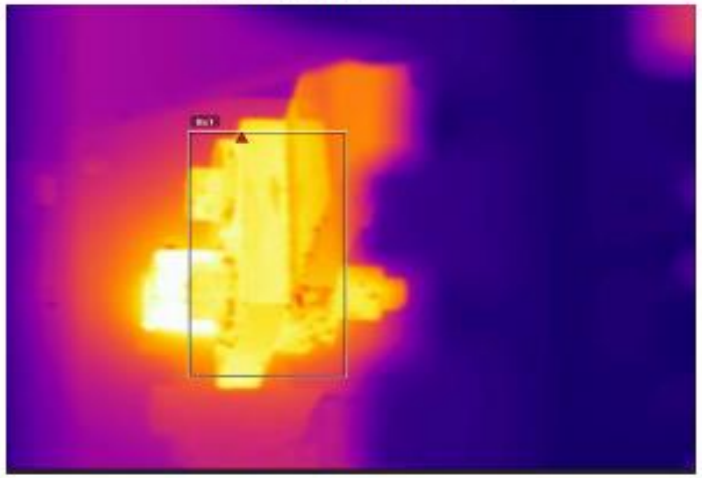


DIGITAL IMAGE (Phase A)

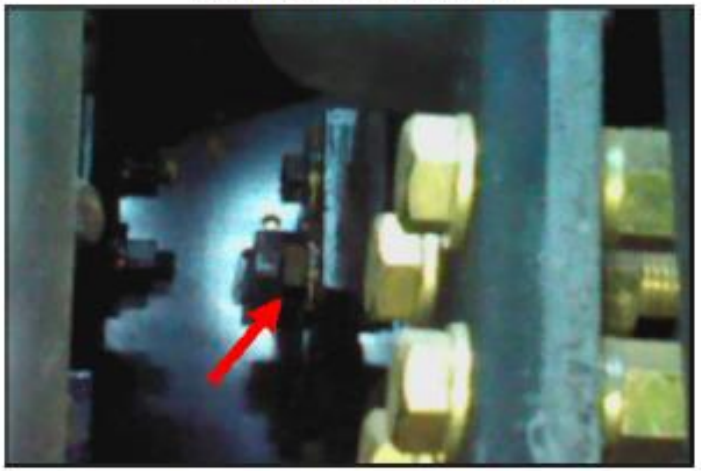


AIR CIRCUIT BREAKER
480V, 3 PHASE

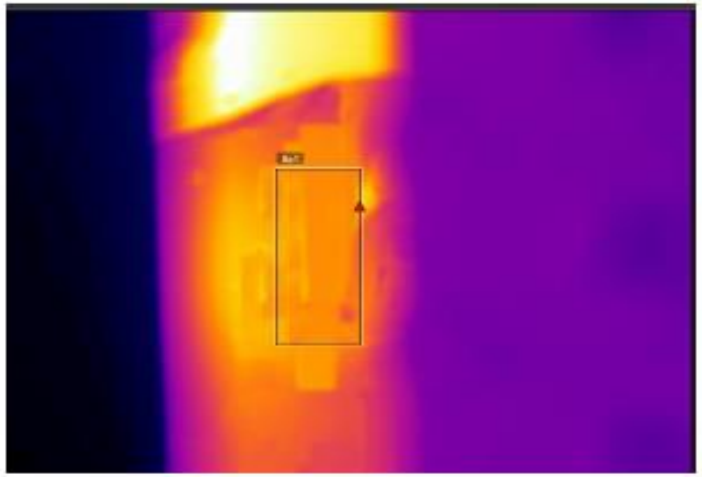
THERMAL IMAGE (Phase B)



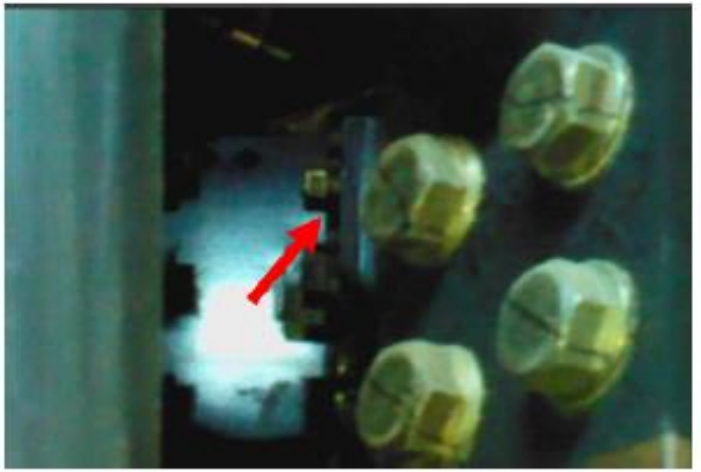
DIGITAL IMAGE (Phase B)



THERMAL IMAGE (Phase C)



DIGITAL IMAGE (Phase C)



PREPARED BY:

ITC-LEVEL 1 CERTIFIED

REVIEWED BY:

ITC-LEVEL 2 CERTIFIED

ITC- Infrared **Thermography** Certification is the gold-standard qualification within the **thermography** industry. **ITC** certification verifies that a thermographer can:

Operate an infrared camera.

B.A. SERVINO
ITC-L1 CERTIFIED

I.V. ESCOPETE, JR.
ITC- LEVEL 2 CERTIFIED

Guidelines from Maintenance Testing Specifications for Electrical Power Distribution Equipment and System		
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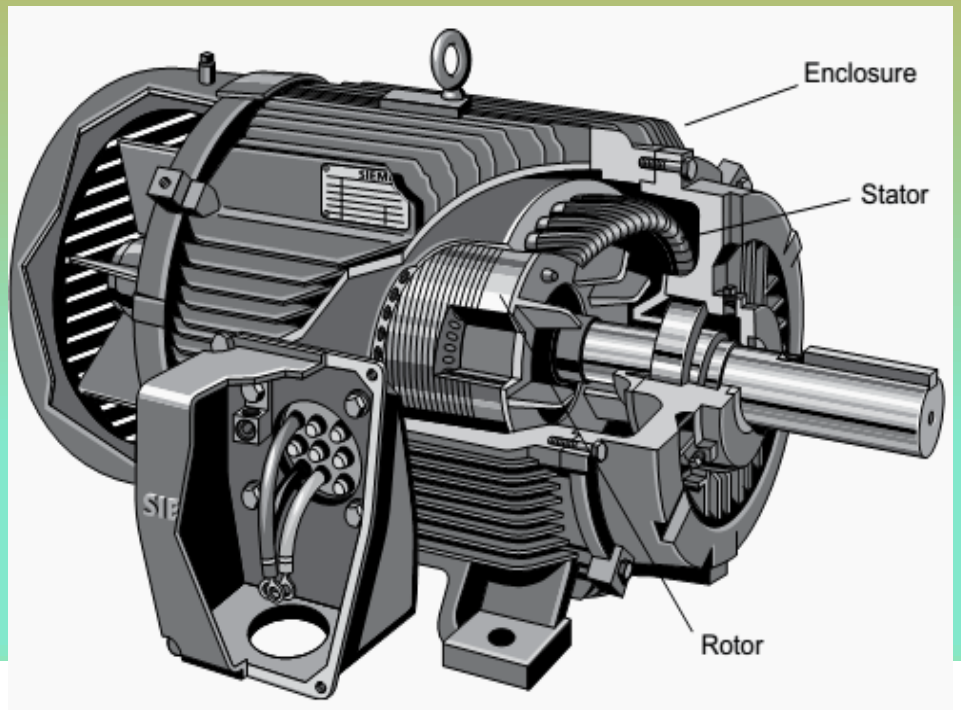
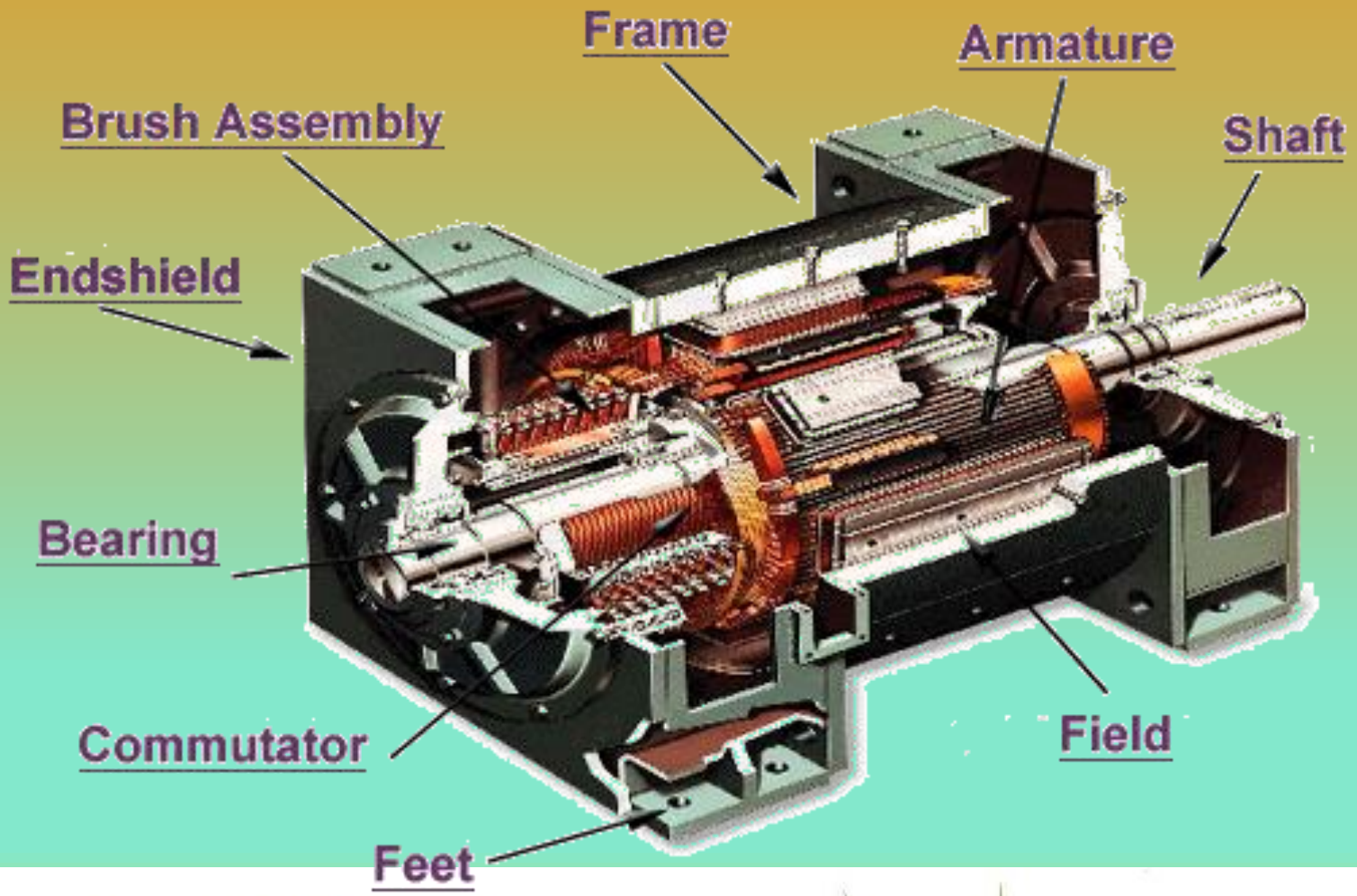
Semi Critical	4 to 15 °C	*Indicate deficiency; REPAIR AS TIME PERMITS*
Critical	16 °C and above	*Indicate major deficiency; REPAIR IMMEDIATELY*

- 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.



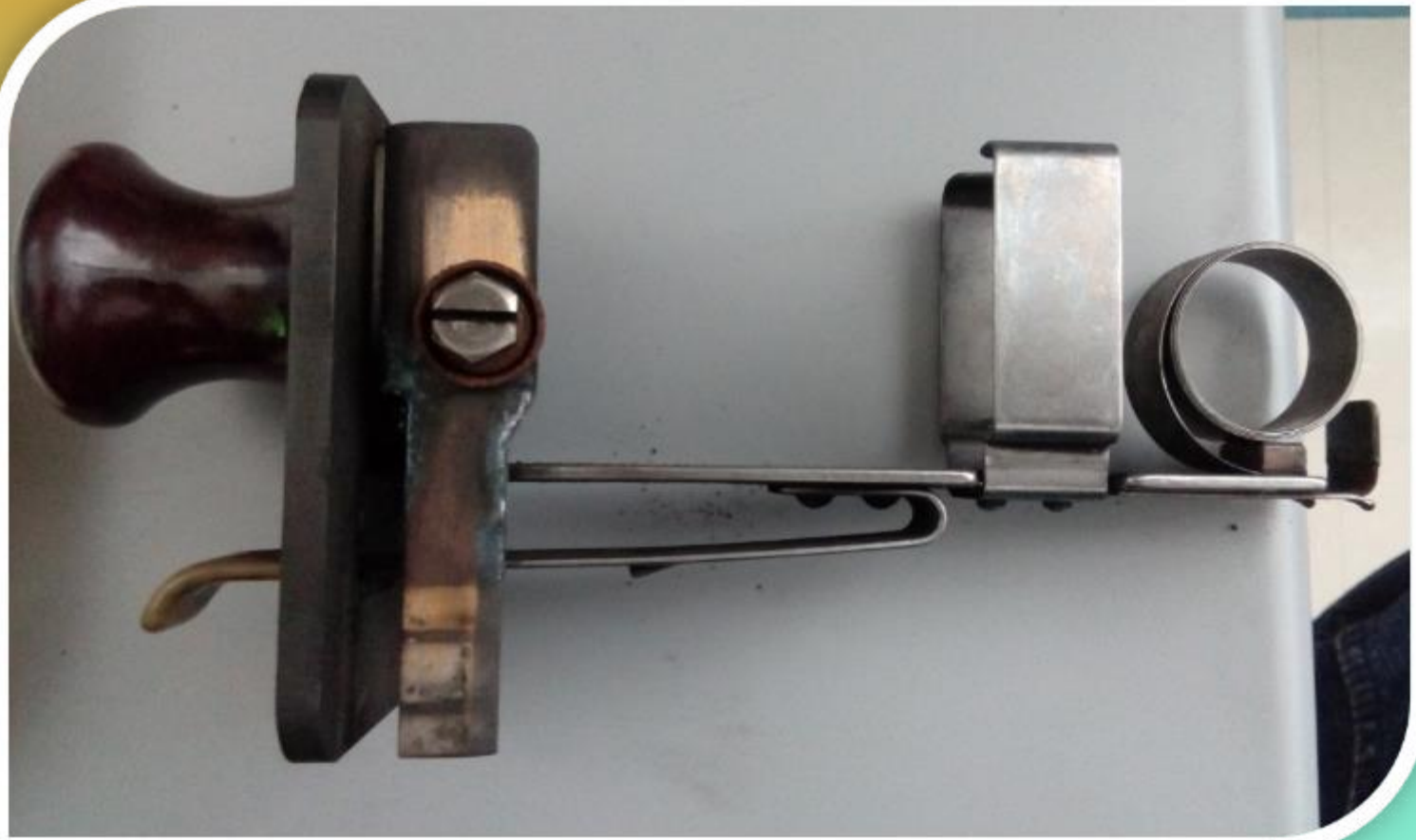
Large Motor – 4.16kv – 700hp

Generator

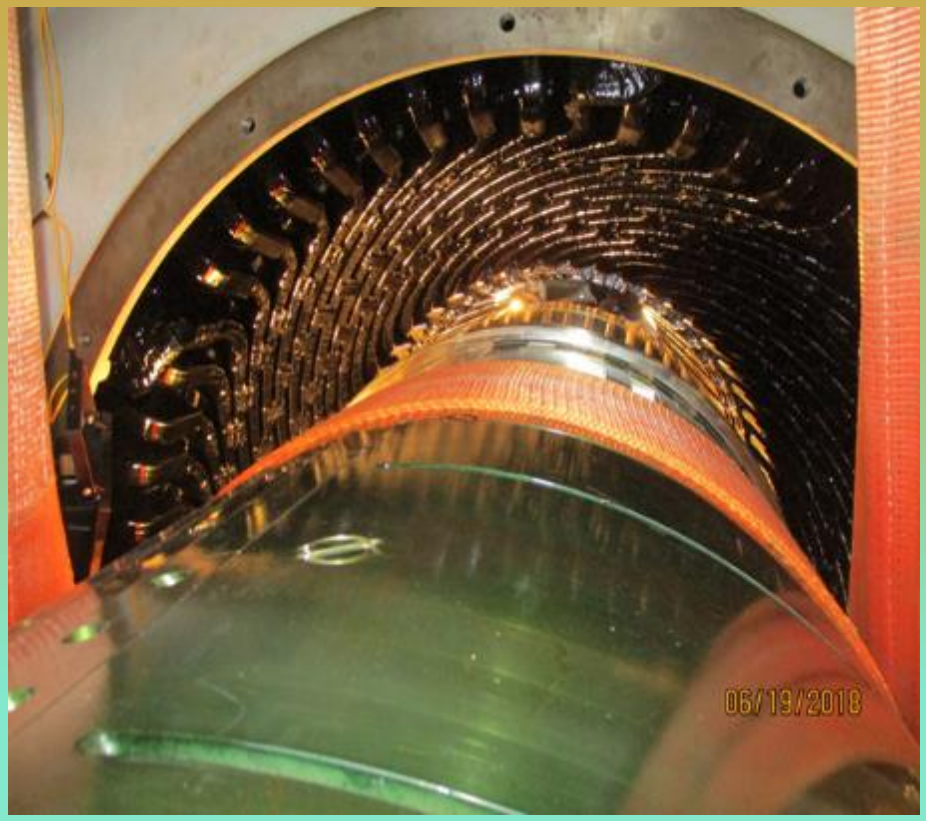

Frame
Armature
Brush Assembly
Shaft
Endshield
Bearing
Commutator
Field
Feet

Exciter Carbon Brush Assembly

Overheating



Stator windings – 60 MW



CERTIFICATE OF CONFORMANCE

Distinguishing number or mark	Description	Working Load Limit (WLL)
561221	"SUPERLIFT" Polyester Web Sling, 6" x 6Mtrs. Color: Brown	6.00 tons
561223	"SUPERLIFT" Polyester Web Sling, 6" x 6Mtrs. Color: Brown	6.00 tons

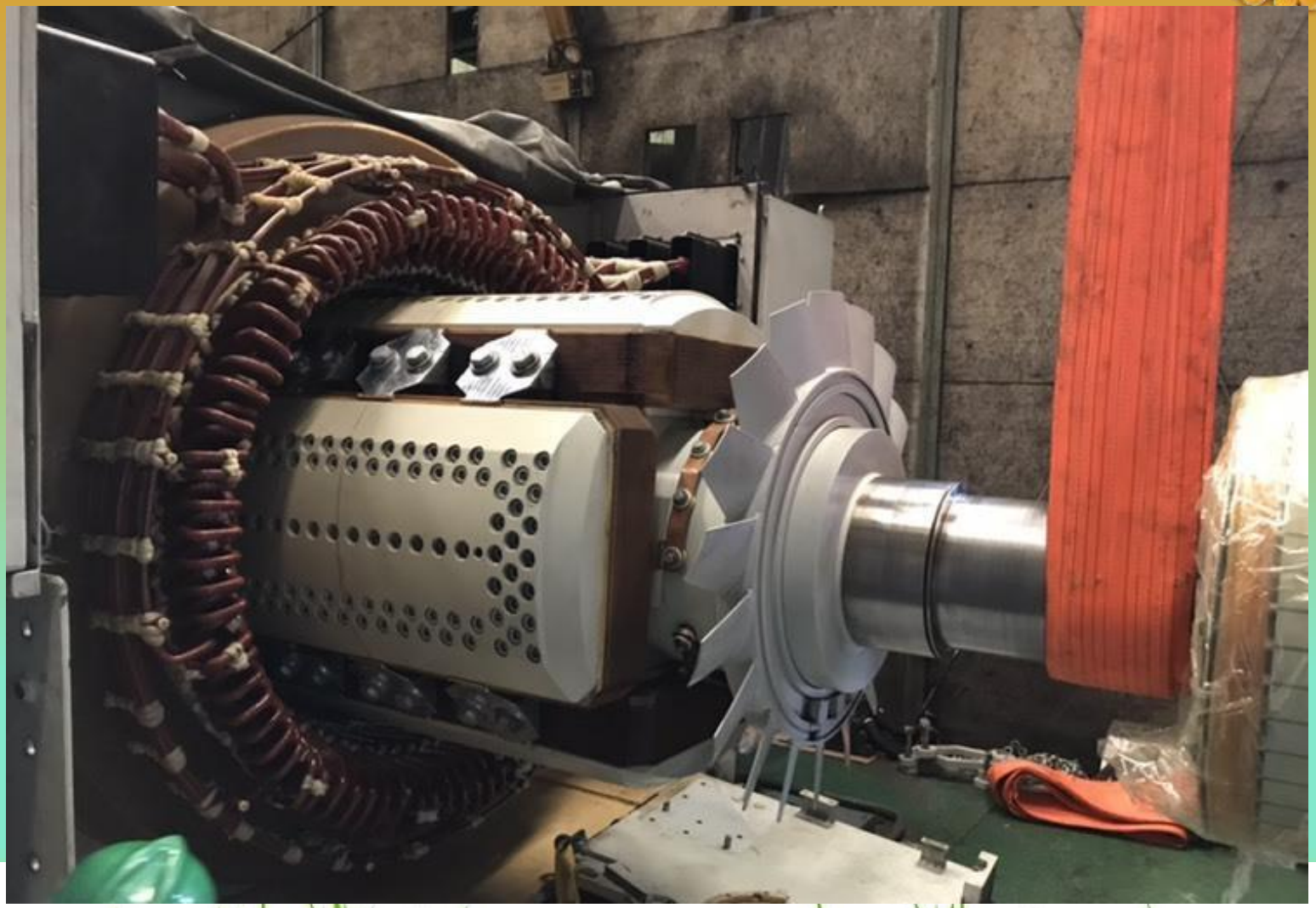
CERTIFICATE OF CONFORMANCE

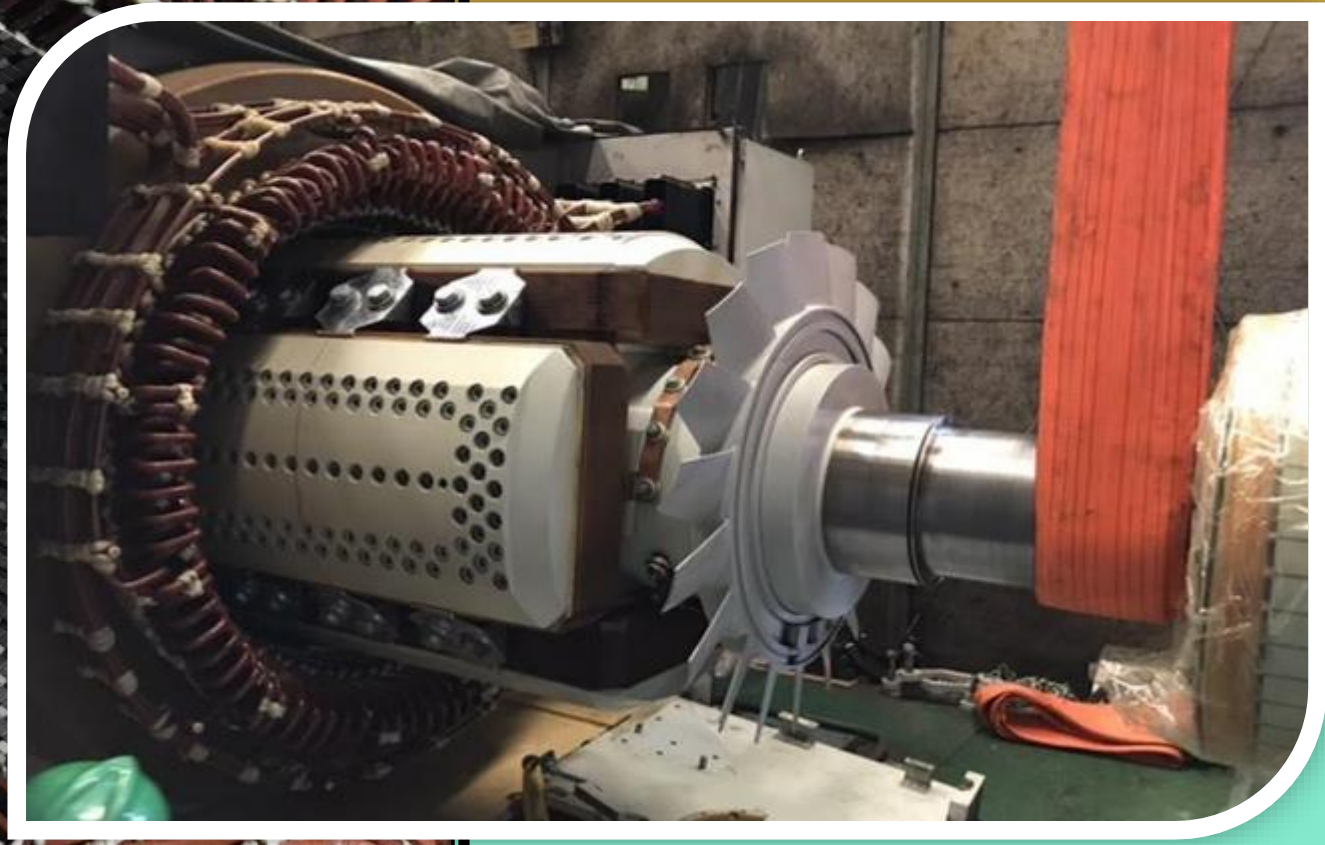
POLYESTER WEBBING SLING TO BS:3481 PART2:1983
POLYESTER ROUND SLING TO BS:6668 PART2:1987
SAFETY FACTOR: 6:1

Distinguish Number or mark (if any)	Description of gear.	Quantity	Date	Working Load Limit
	POLYESTER WEBBING SLING			STRAIGHT PULL
SUPERLIFT 65 2486	WIDTH 4" TYPE DEE COLOR GREY LENGTH 3M SAFETY FACTOR 6:1	1 PC	2016-11-8	4,000 KG

12tons - Rotor

Pull out of rotor – using web sling





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

Permit to work with associated electrical permit

LOCKOUT/TAGOUT

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:

- **OSHA 29 CFR 1910.147, 1910.212 and 1919.219.**
- **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) 642-4900**

It's true...

YOLO

You Only Live Once

So always...

LOTO

Lock Out Tag Out


clfjr2018ANCliee

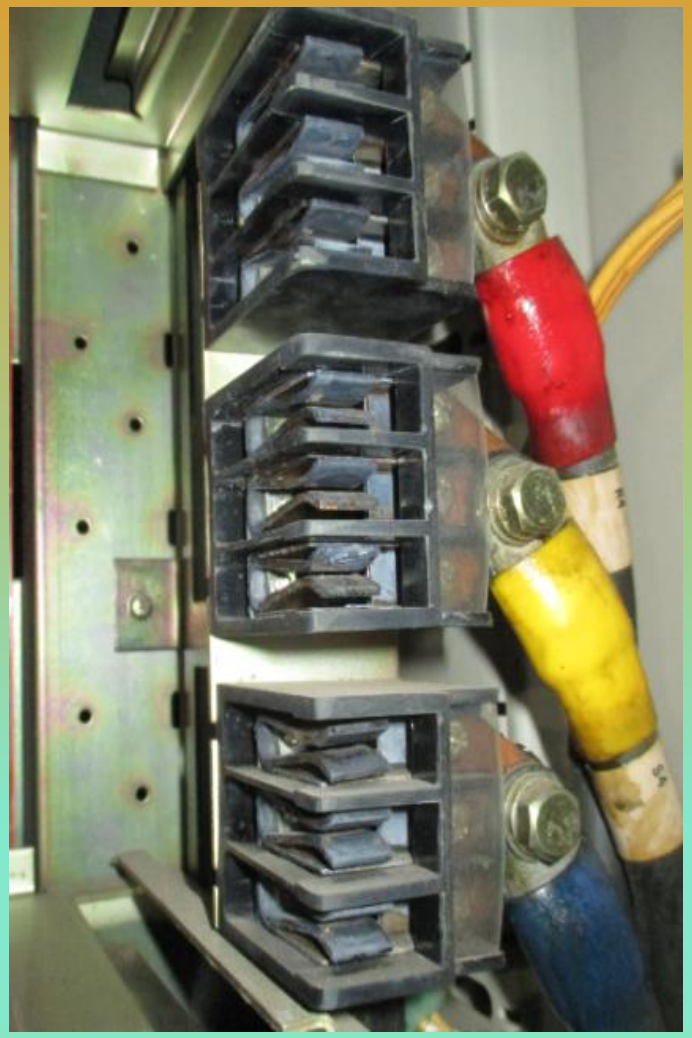

dfjr2018ANCIllee


clfjr2018ANCIilee

Indoor Substation


TOSHIBA
CLOSING BUTTON
TRIP BUTTON
AIR CIRCUIT BREAKER
06/29/201


05/30/

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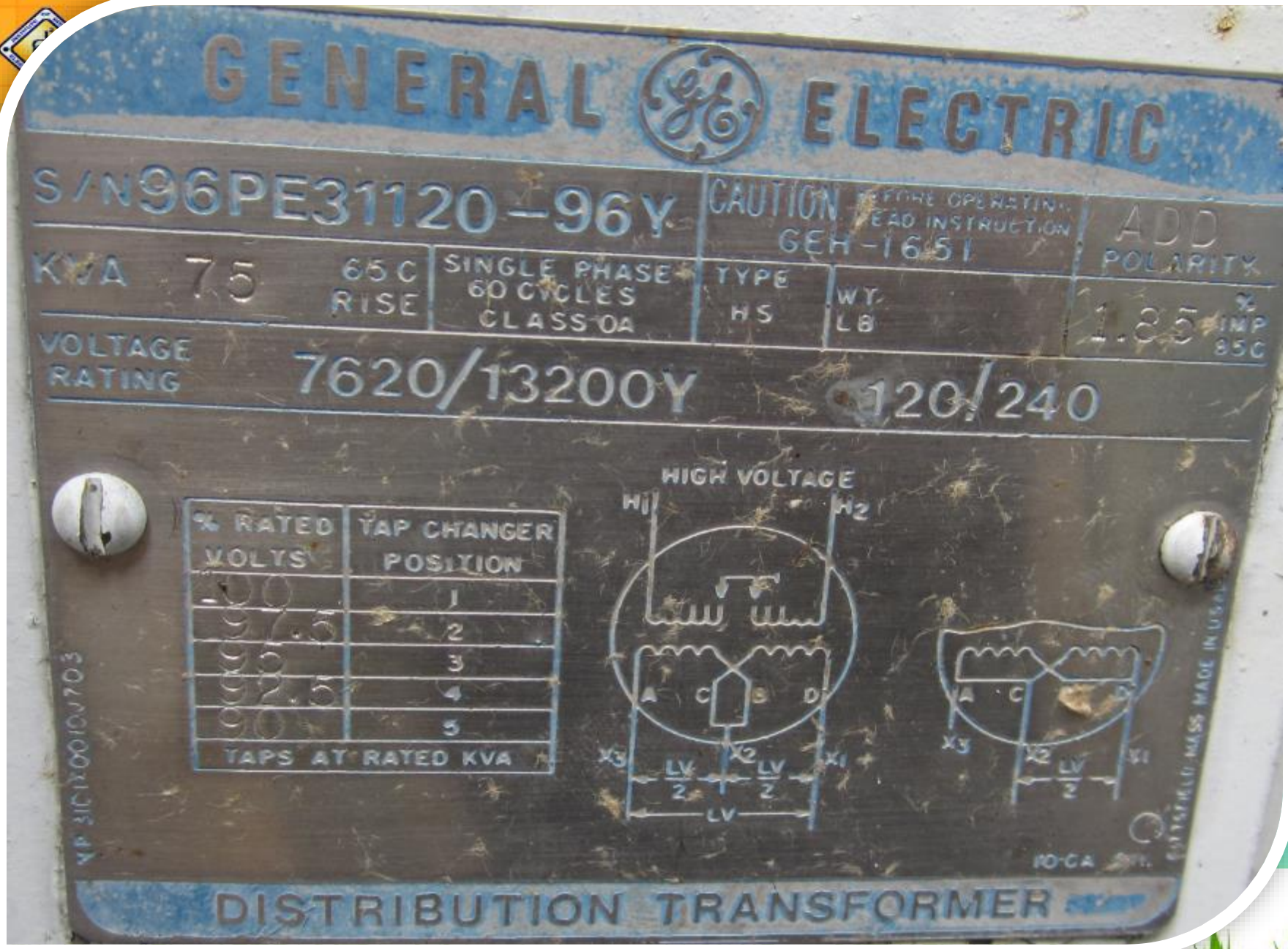
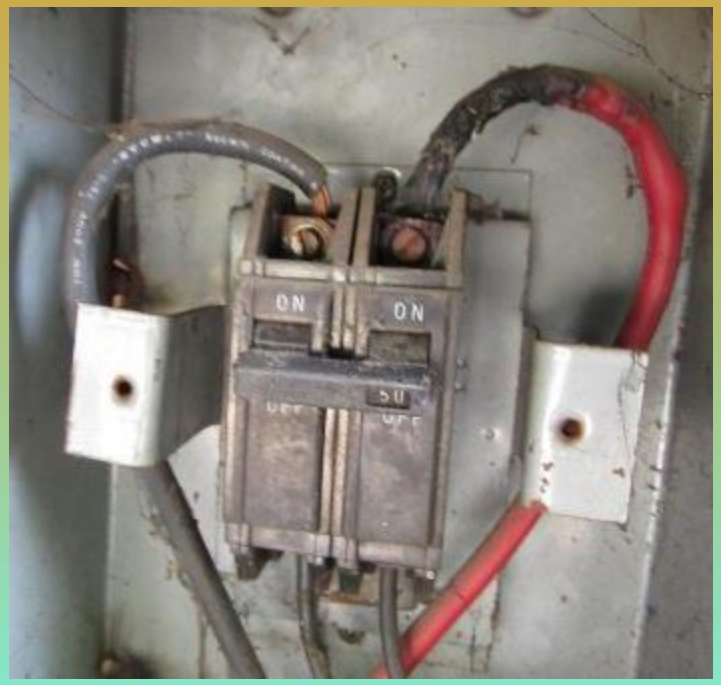

GENERAL ELECTRIC
S/N 96PE31120-96Y
CAUTION BEFORE OPERATING READ INSTRUCTION GEH-1651
ADD POLARITY
KVA 75
65 C RISE
SINGLE PHASE 60 CYCLES CLASS OA
TYPE HS
WT. LB
1.85 % IMP 85C
VOLTAGE RATING
7620/13200Y
120/240
% RATED VOLTS
TAP CHANGER POSITION
105
102.5
100
97.5
95
92.5
90
1
2
3
4
5
TAPS AT RATED KVA
HIGH VOLTAGE
H1
H2
A
C
B
D
X3
X2
X1
LV/2
LV/2
LV
DISTRIBUTION TRANSFORMER


250
TESTED
X-P3584
03/24/2017


250
X-P3584
250
X-P3584
03/24/2017

Circuit breaker



Possible Preventive Maintenance Schedule for Electrical Apparatus in a Petrochemical Process Plant

Electrical Apparatus	Preventive Maintenance	PM Frequency: Weekly	Monthly	Annually	Every 2 Years	Every 3 Years	Change Only If Required
Battery Systems	Check Voltage		●				
	Check Voltage Alarm		●				
	Specific Gravity and Plates			●			
Emergency Transfer Schemes	Standby Generators—run up	●					
	Complete Transfer		●				
Main Circuit Breakers	Operational Check			●			
	Oil Inspection				●		
Main Substation Transformers	Temperature & Load Check		●				
	Oil Inspection				●		
Motors	Bearings						●
	Grease*						●
	Ventilation						●
Protection	Cleaned and Checked for Calibration					●	
	Kilowatt-hour Meters					●	
Substation High Voltage	Incoming Lines—Dirty Atmos			●			
	Incoming Lines—Clean Areas				●		
Unit Substations	Ground Indicators		●				
	Sump Pump		●				
	Housekeeping		●				
	Temperature & Load Check			●			
	Oil Inspection—Transformers				●		

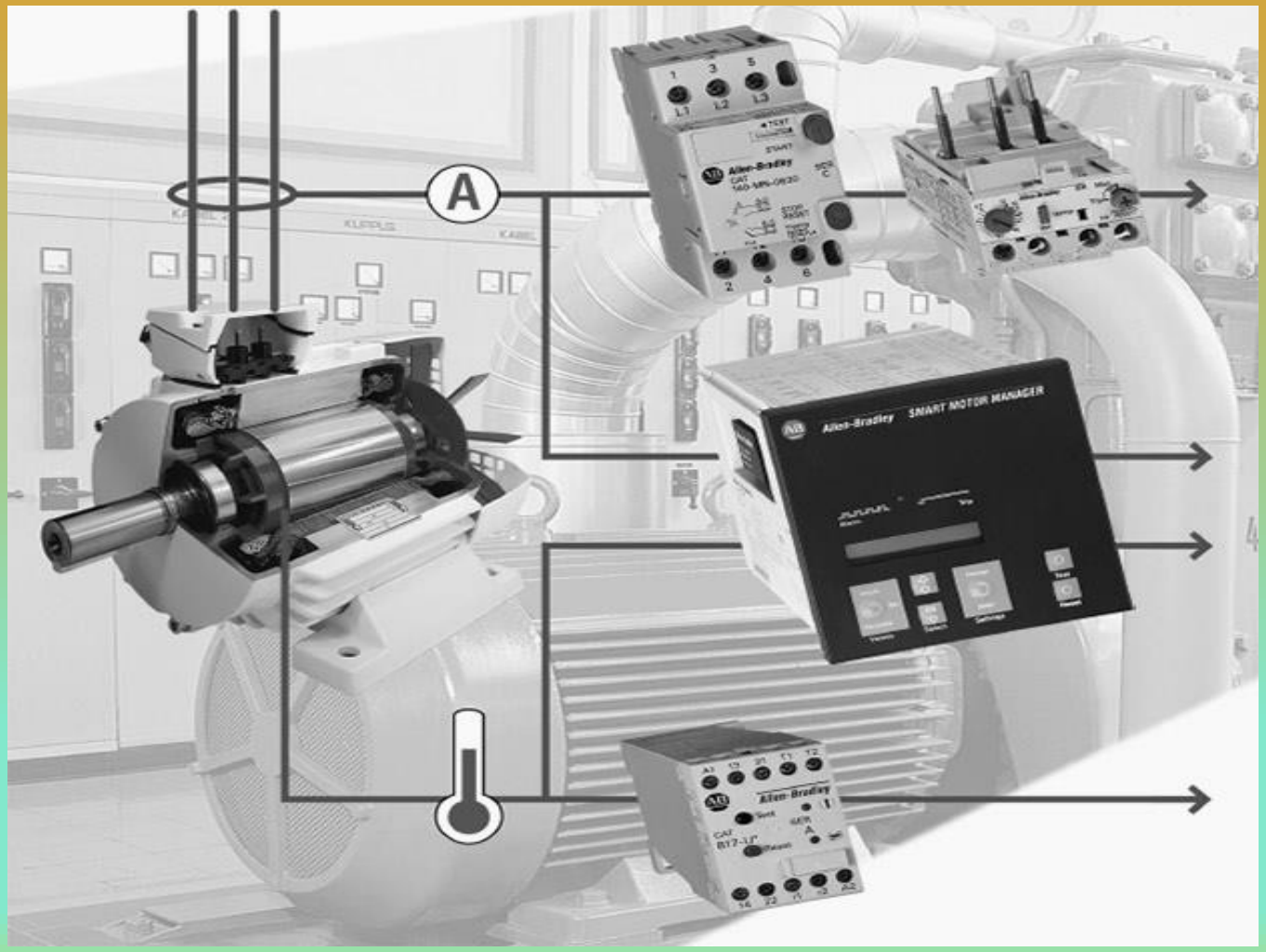

EEP
ELECTRICAL
ENGINEERING PORTAL

Planned maintenance

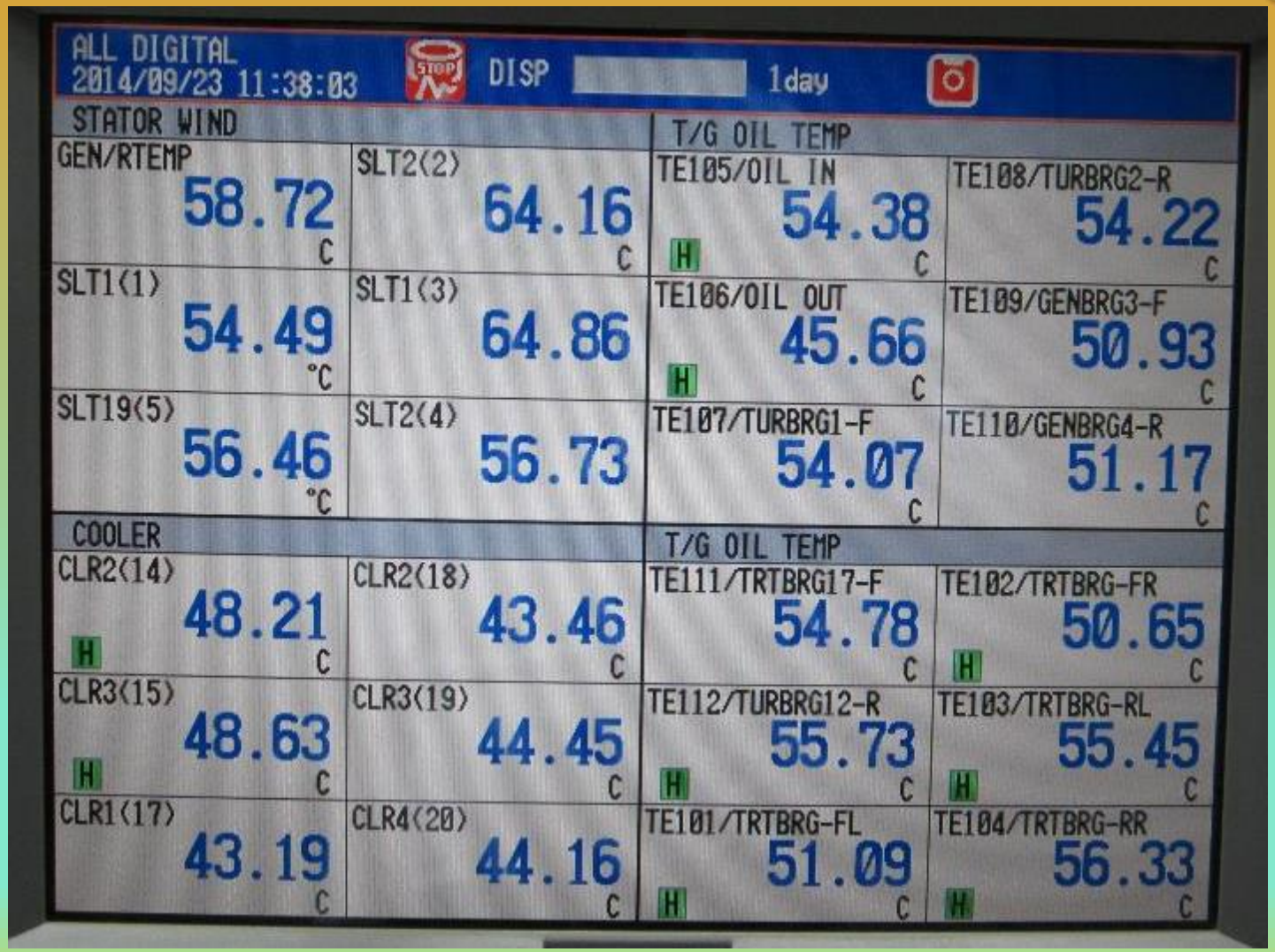
CM

- 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)

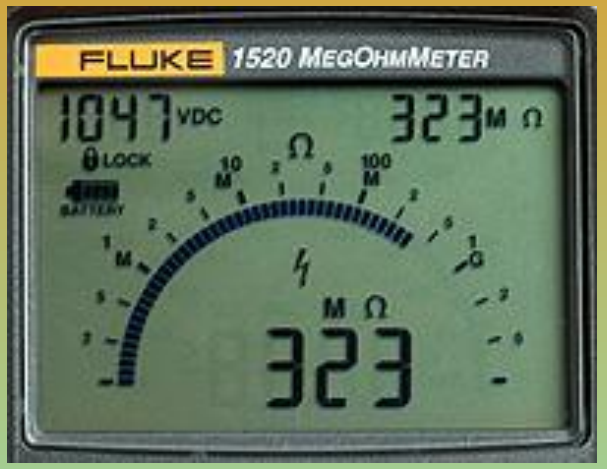
On line monitoring system



On line monitoring system

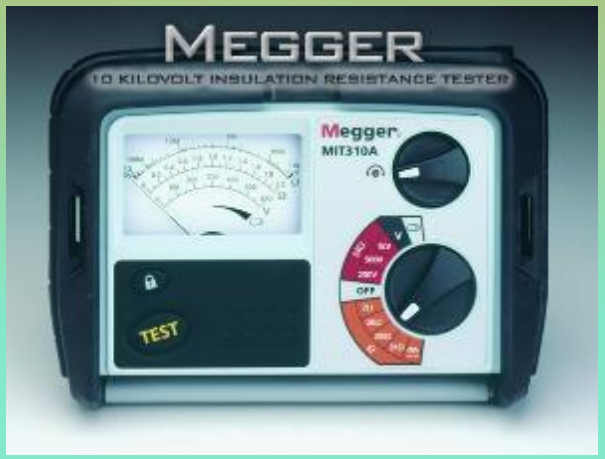



Maintenance
Management
Of
Electrical
Equipment
(Condition
Monitoring
Based)
Part 4
EEP


FLUKE 1520 MEGOHMMETER
1047 VDC
323 MΩ
LOCK
BATTERY
323

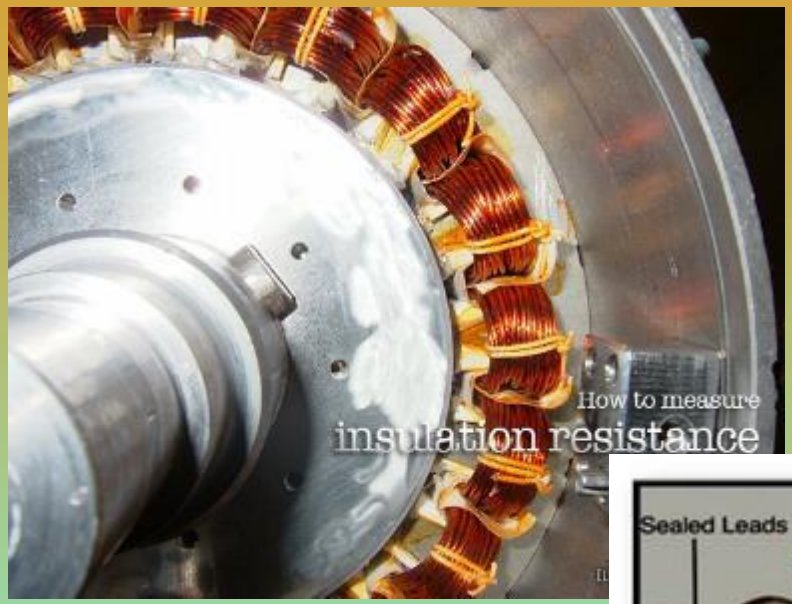

10
Important
Precautions
When
Working
On
Low
Voltage
Energized
Equipment
EEP

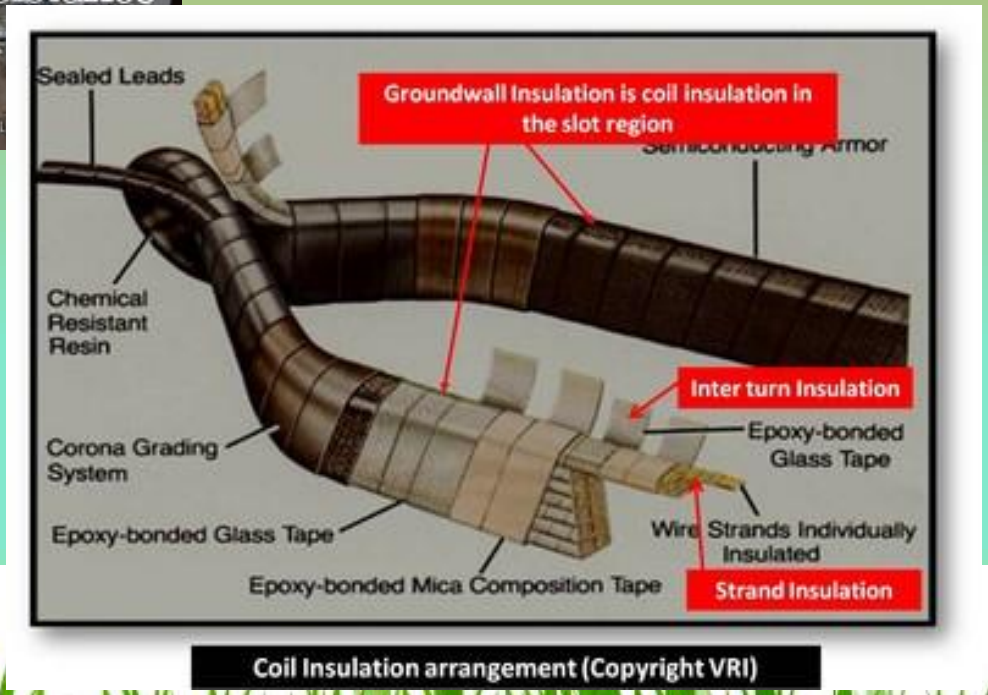

5249V
155


MEGGER
10 KILOVOLT INSULATION RESISTANCE TESTER
Megger
MIT310A
TEST


Megger
Megger DET3TA
TEST

How to measure Insulation resistance



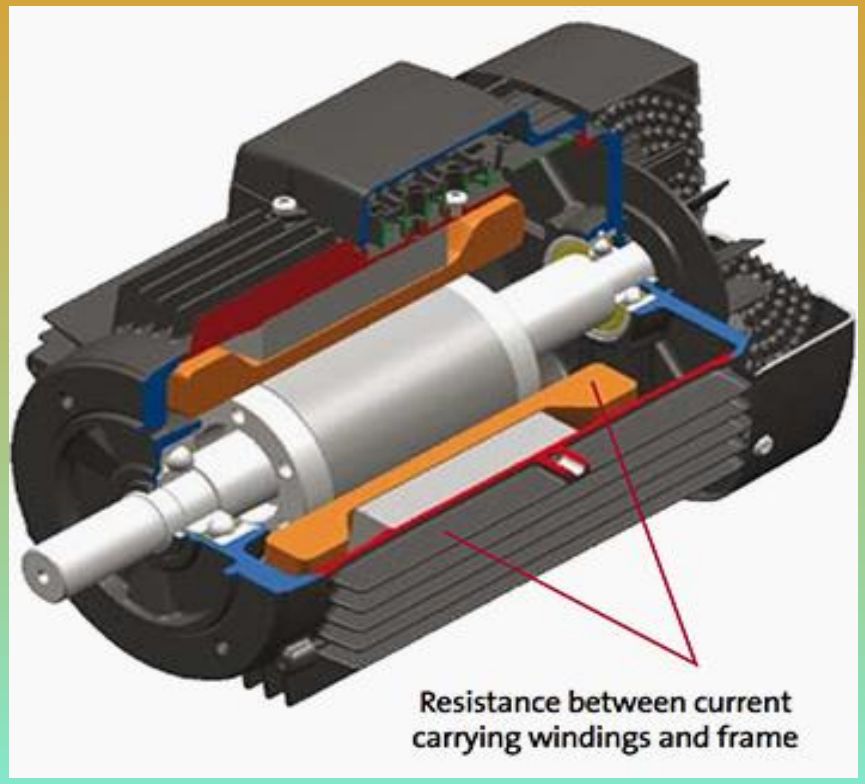


Coil Insulation arrangement (Copyright VRI)

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.

How to measure Insulation resistance



Ground insulation test of a motor

Safety Tips :

During the measurement and immediately afterwards, some of the terminals carry dangerous voltages and MUST NOT BE TOUCHED.

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

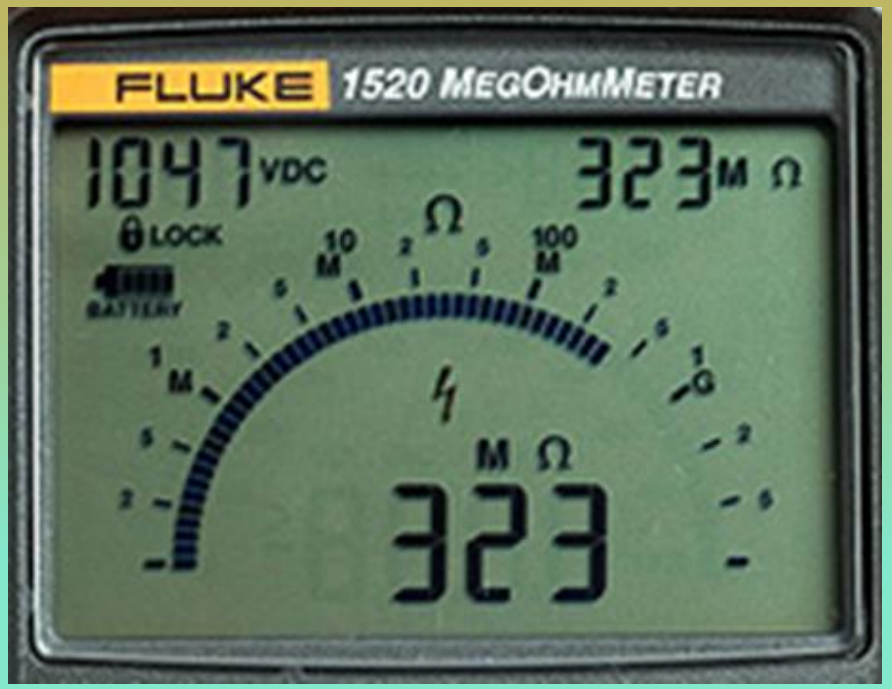
- If the insulation resistance of a new, cleaned or repaired motor that has been stored for some time is less then **10 megaohm**, the reason might be that the windings are humid and need to be dried.
- If the motor has been operating for a long period of time, the minimum insulation resistance **may 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.

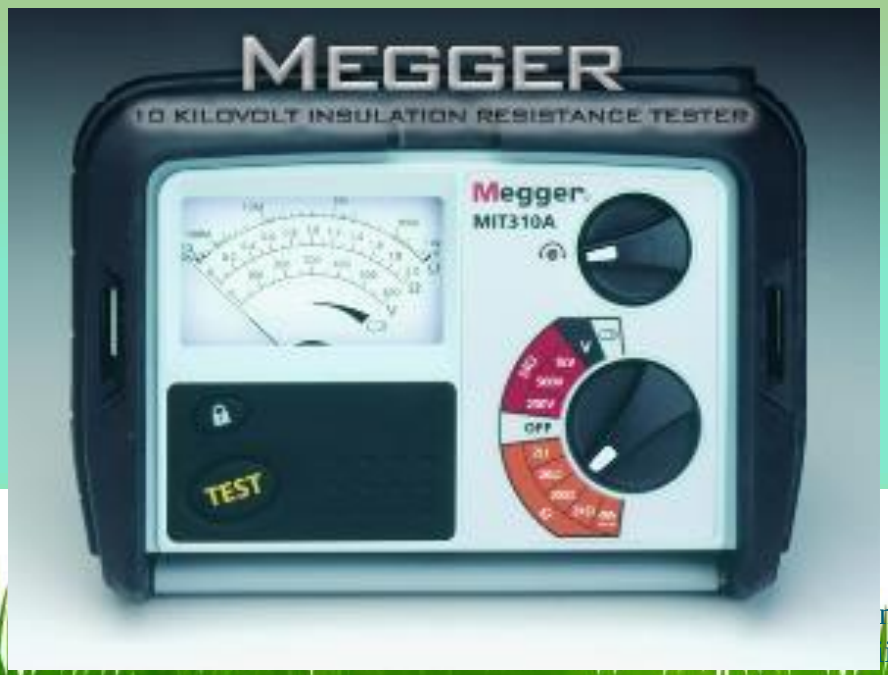
Factors affecting the winding insulation resistance

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.


Megger


FLUKE 1520 MEGOHMMETER
1047 VDC
323 MΩ
LOCK
BATTERY
323


MEGGER
10 KILOVOLT INSULATION RESISTANCE TESTER
Megger
MIT310A
TEST
OFF

BM

- **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.

5W1H

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.

6M

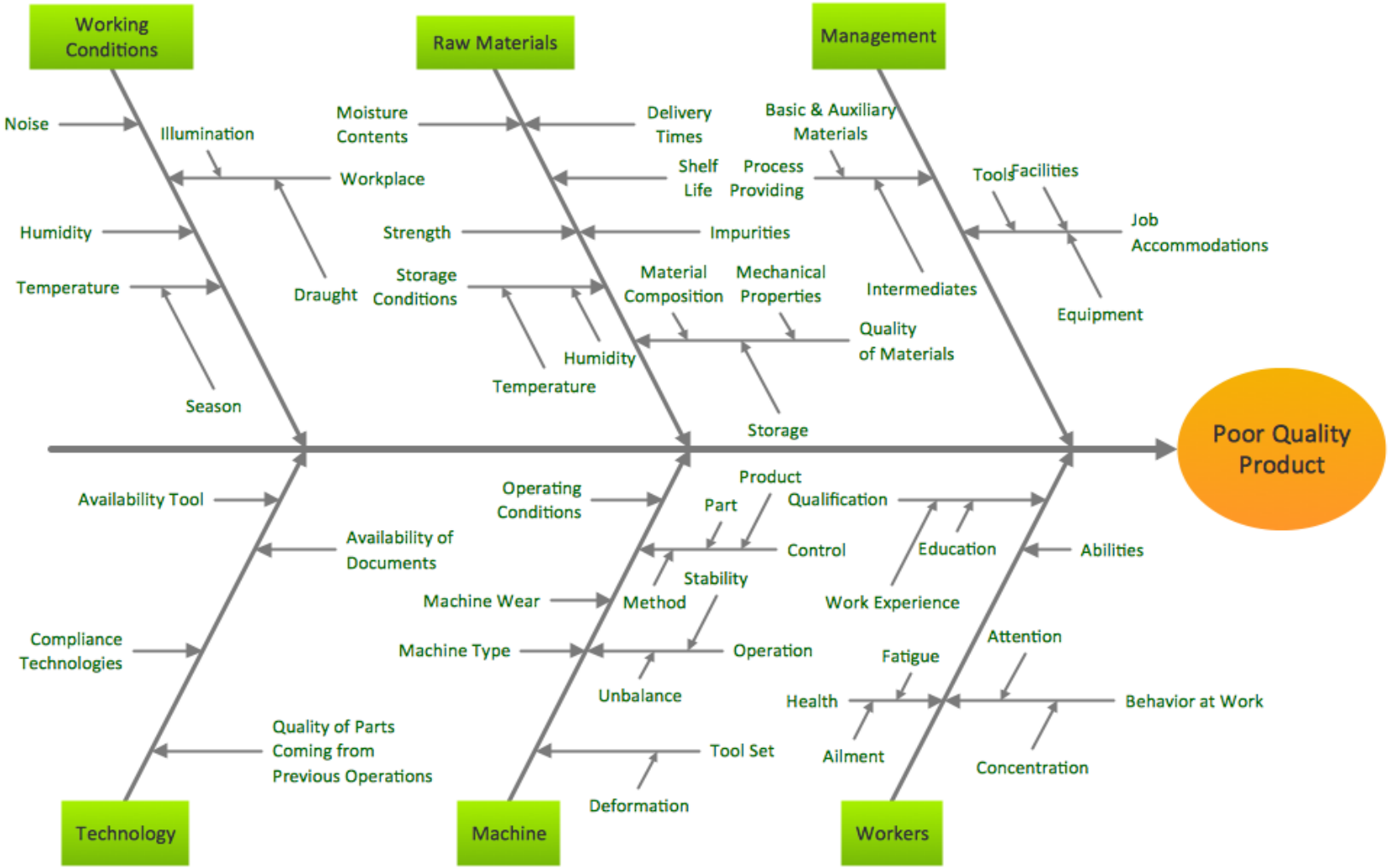
1. Manpower
2. Machinery
3. Materials
4. Method
5. Mother-nature
6. Measurement

8P

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



Air circuit breaker

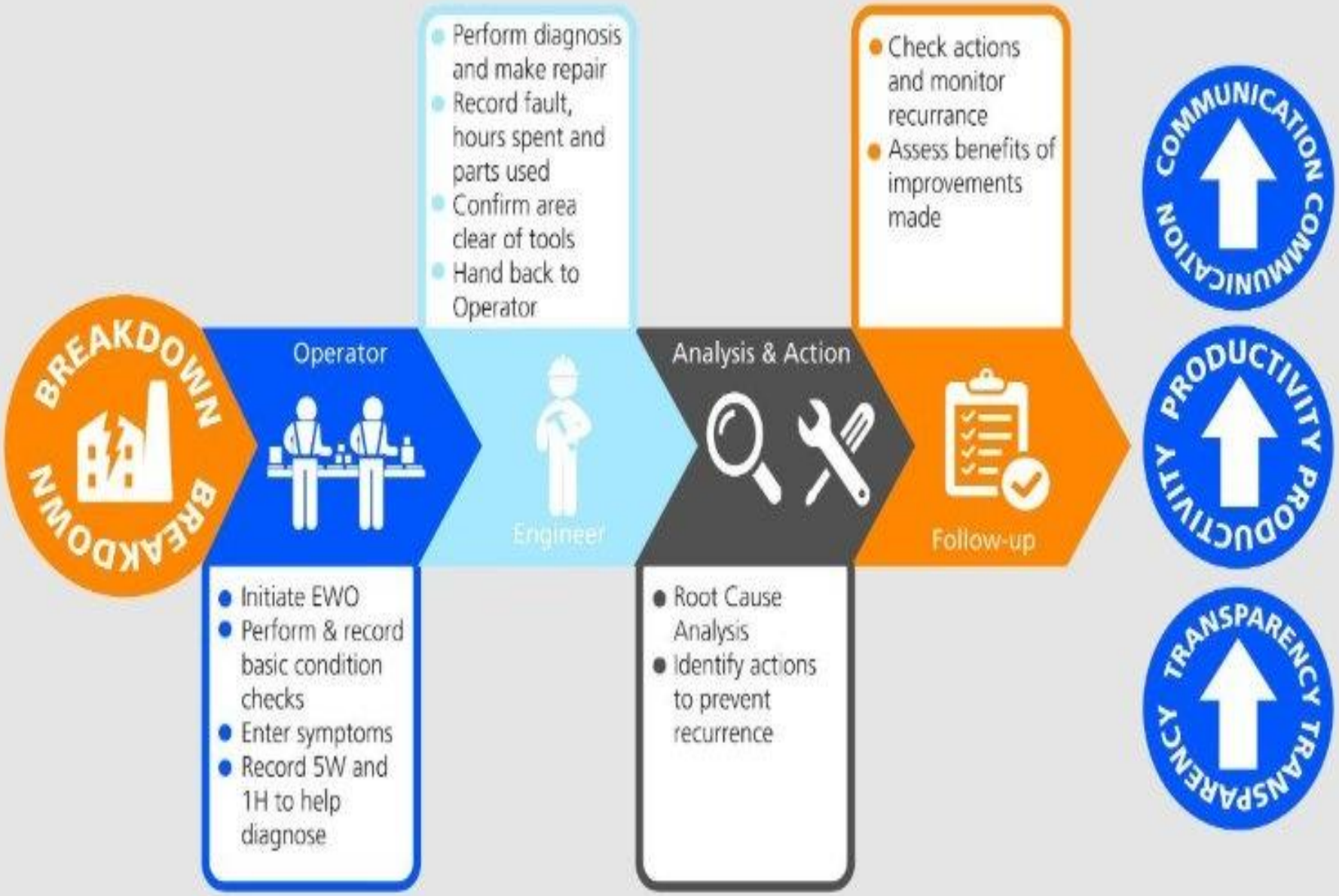

BREAKDOWN
BREAKDOWN
Operator
Initiate EWO
Perform & record basic condition checks
Enter symptoms
Record 5W and 1H to help diagnose
Engineer
Perform diagnosis and make repair
Record fault, hours spent and parts used
Confirm area clear of tools
Hand back to Operator
Analysis & Action
Root Cause Analysis
Identify actions to prevent recurrence
Follow-up
Check actions and monitor recurrance
Assess benefits of improvements made
COMMUNICATION
COMMUNICATION
PRODUCTIVITY
PRODUCTIVITY
TRANSPARENCY
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

Insulation resistance value (Mega-ohms)	Insulation level
2 mega ohms or less	Bad
2-5	Critical
5-10	Abnormal
10-50	Good
50-100	Very good
100 Mega-ohm or more	Excellent

TABLE 100.1
Insulation Test Voltages and Analysis of Test Results

Rated Voltage of Equipment	Recommended Test Voltage*
250	500
600	1,000
1,000	1,000
2,500	1,000
5,000	2,500
8,000	2,500
15,000	2,500
25,000	5,000
34,500 and above	5,000

* These values should only be utilized in the absense 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

Insulation System	Temperature Classification
Class A Class 105	105° C 221 °F
Class E* Class 120	120 °C 248 °F
Class B Class 130	130 °C 266 °F
Class F Class 155	155 °C 311 °F
Class H Class 180	180 °C 356 °F
Class N Class 200	200 °C 392 °F
Class R Class 200	220 °C 428 °F
Class S Class 240	240 °C 464 °F
Class C Class over 240	Over 240 °C Over 464 °F

***Used in European equipment**

GENERATOR BREAKER

DLRO – Digital Low Resistance Ohmmeter

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.

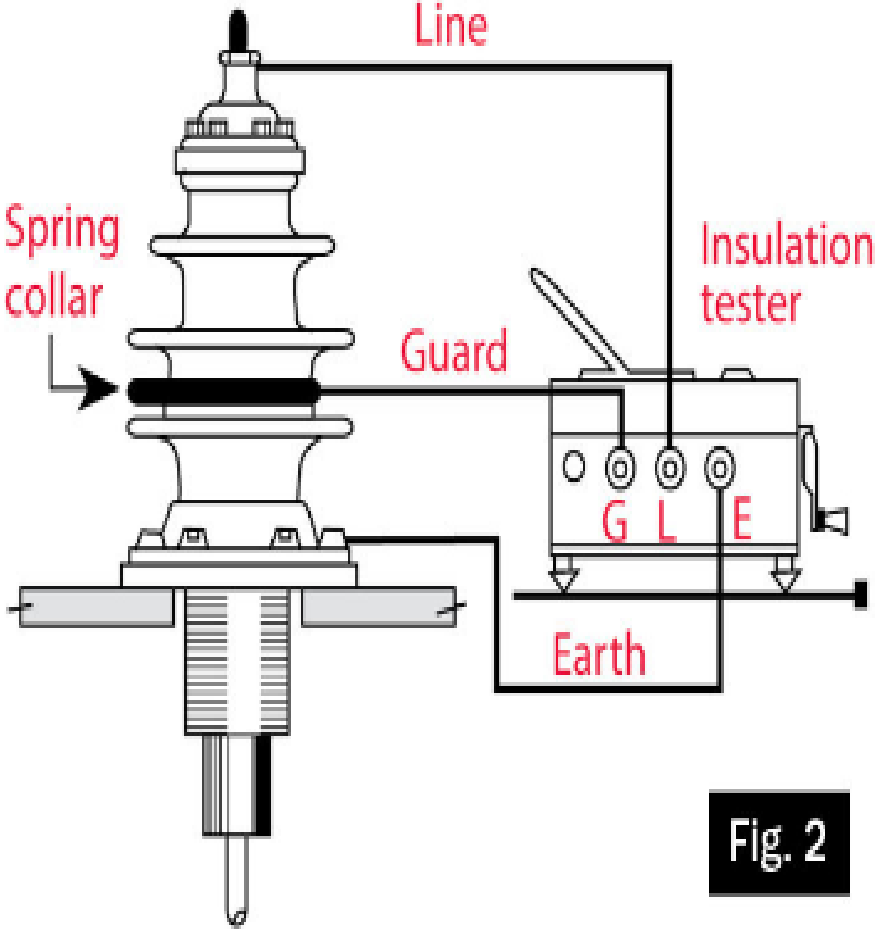
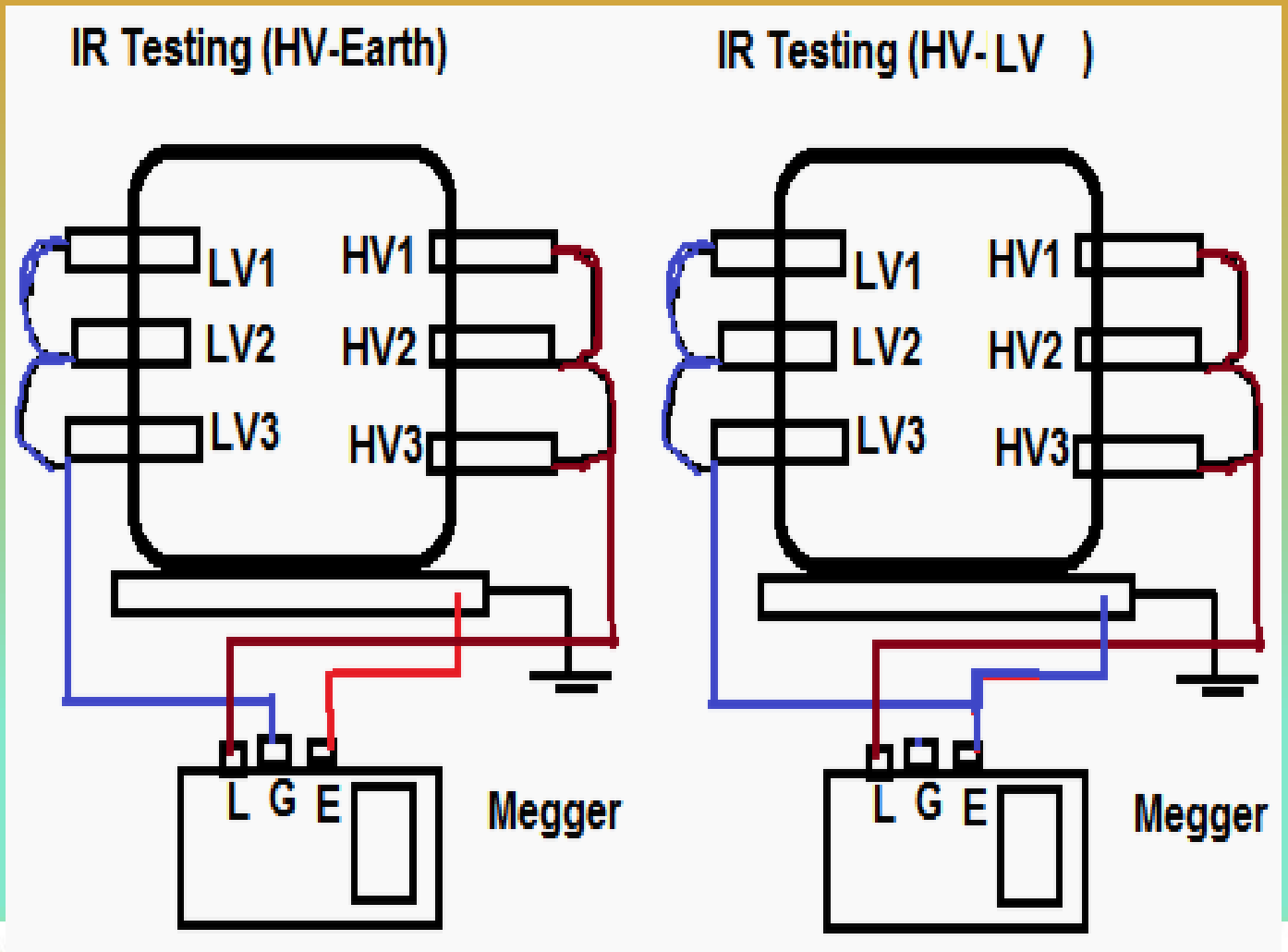
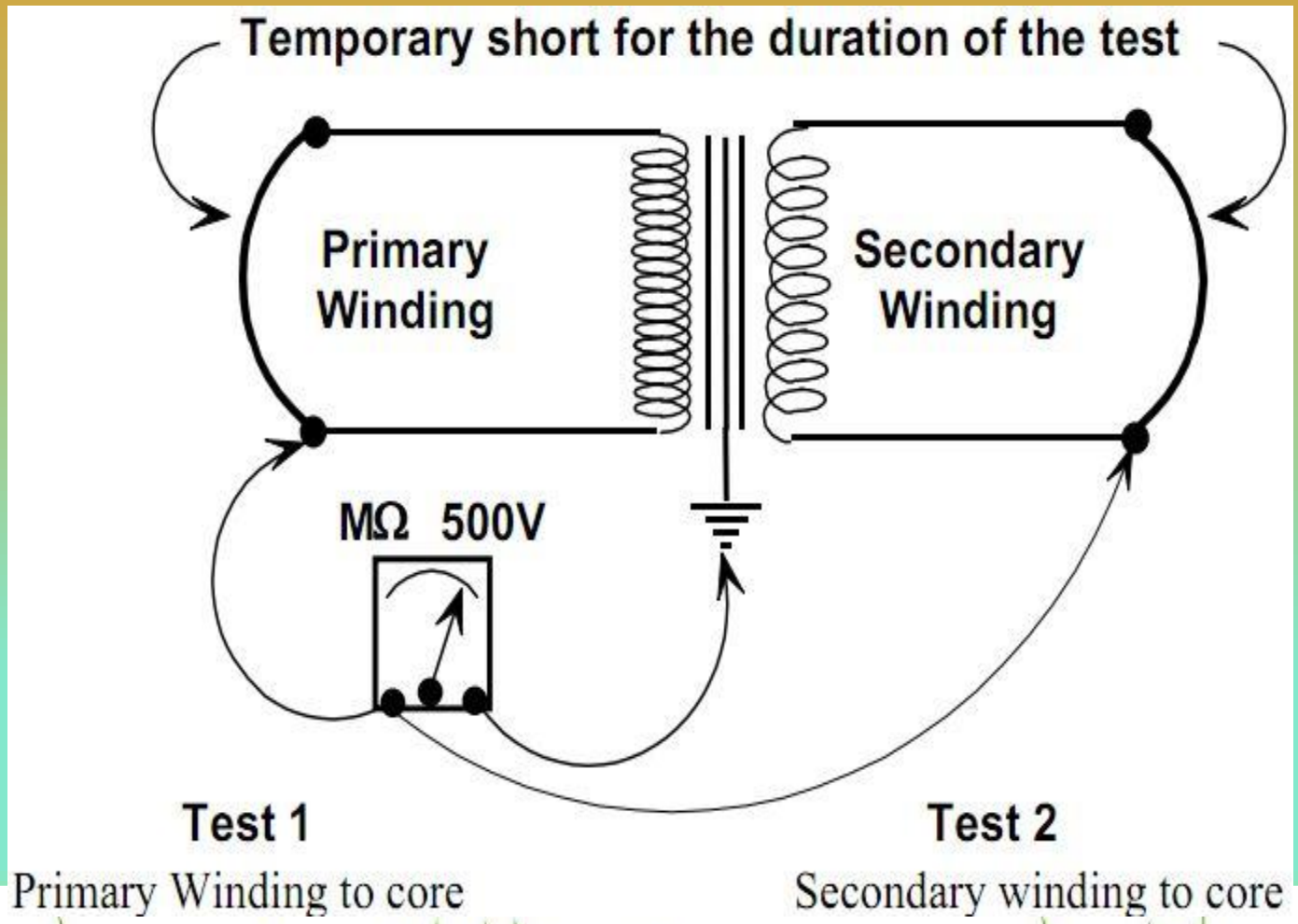
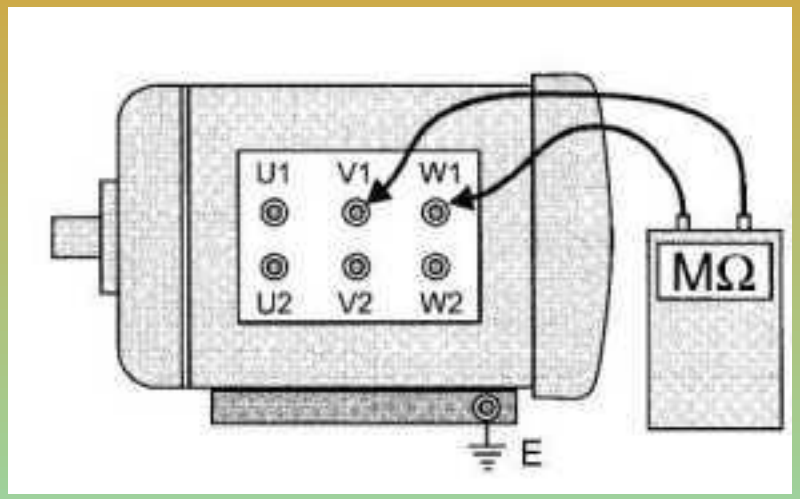


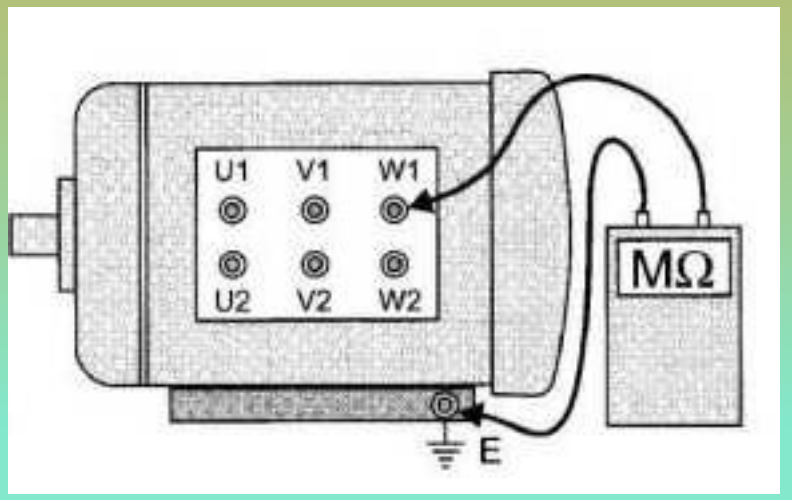
Fig. 2

Various insulation tests


IR Testing (HV-Earth)
LV1
LV2
LV3
HV1
HV2
HV3
L G E
Megger
IR Testing (HV- LV)
LV1
LV2
LV3
HV1
HV2
HV3
L G E
Megger


Temporary short for the duration of the test
Primary Winding
Secondary Winding
MΩ 500V
Test 1
Primary Winding to core
Test 2
Secondary winding to core





Winding to ground

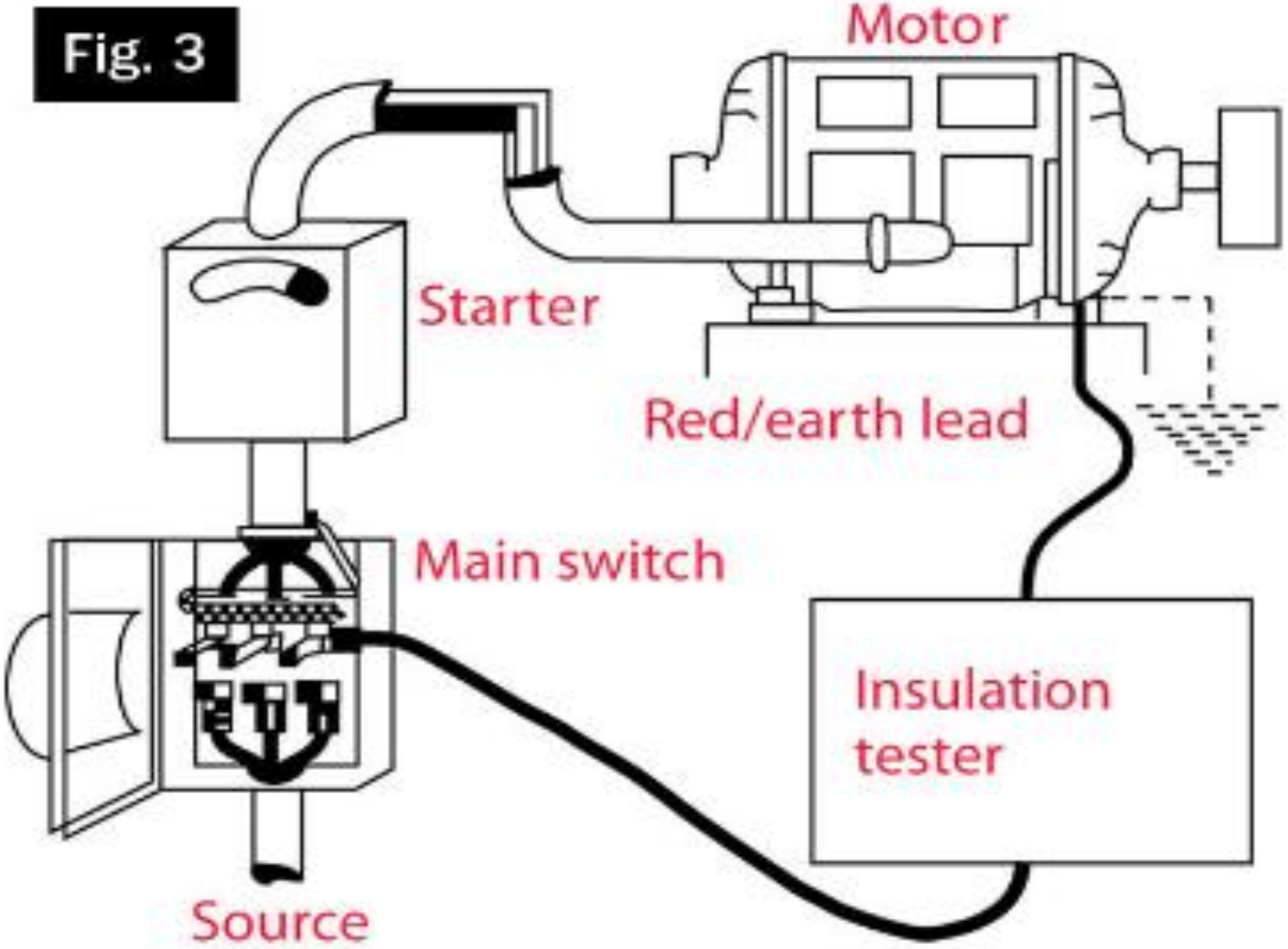


Fig. 3
Motor
Starter
Red/earth lead
Main switch
Insulation tester
Source

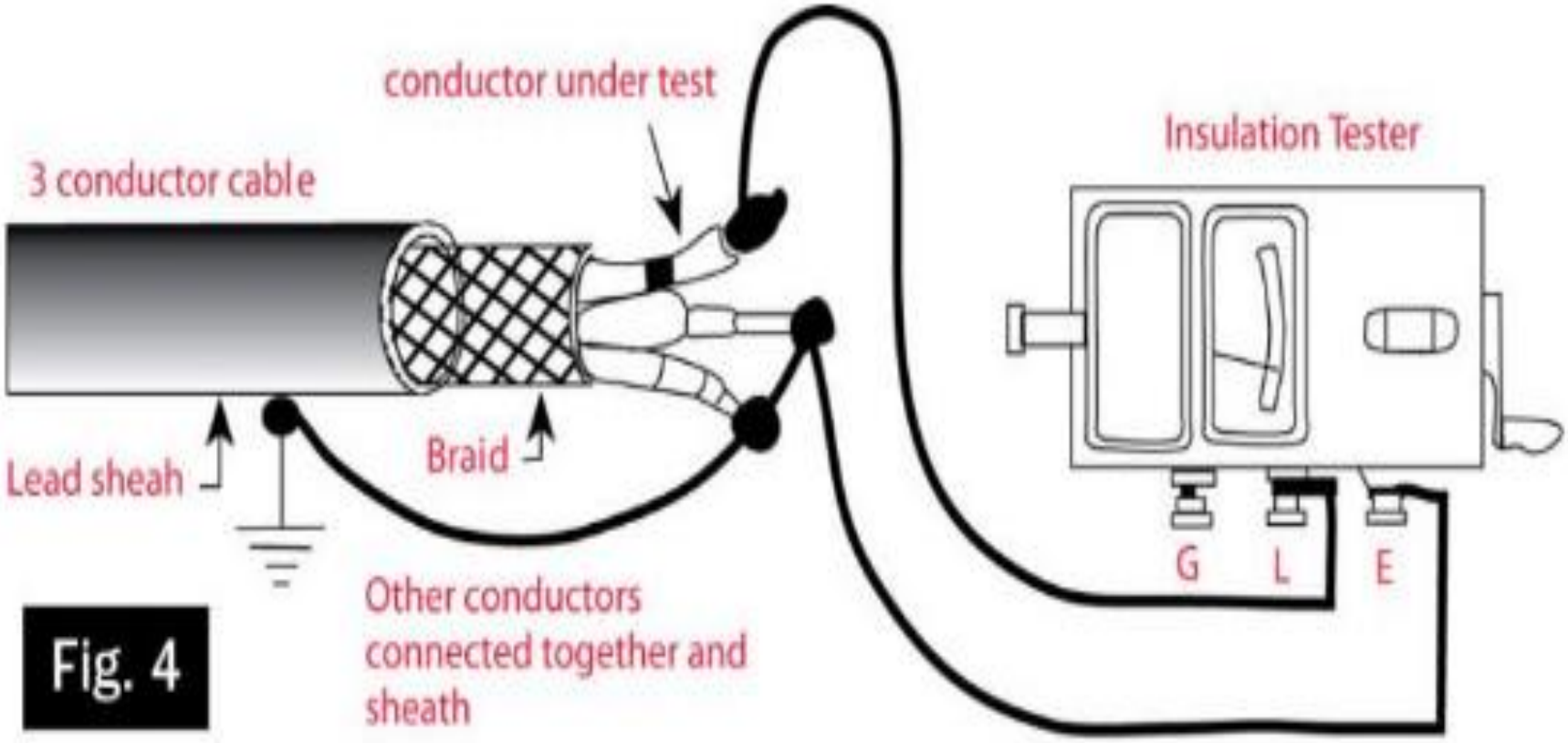
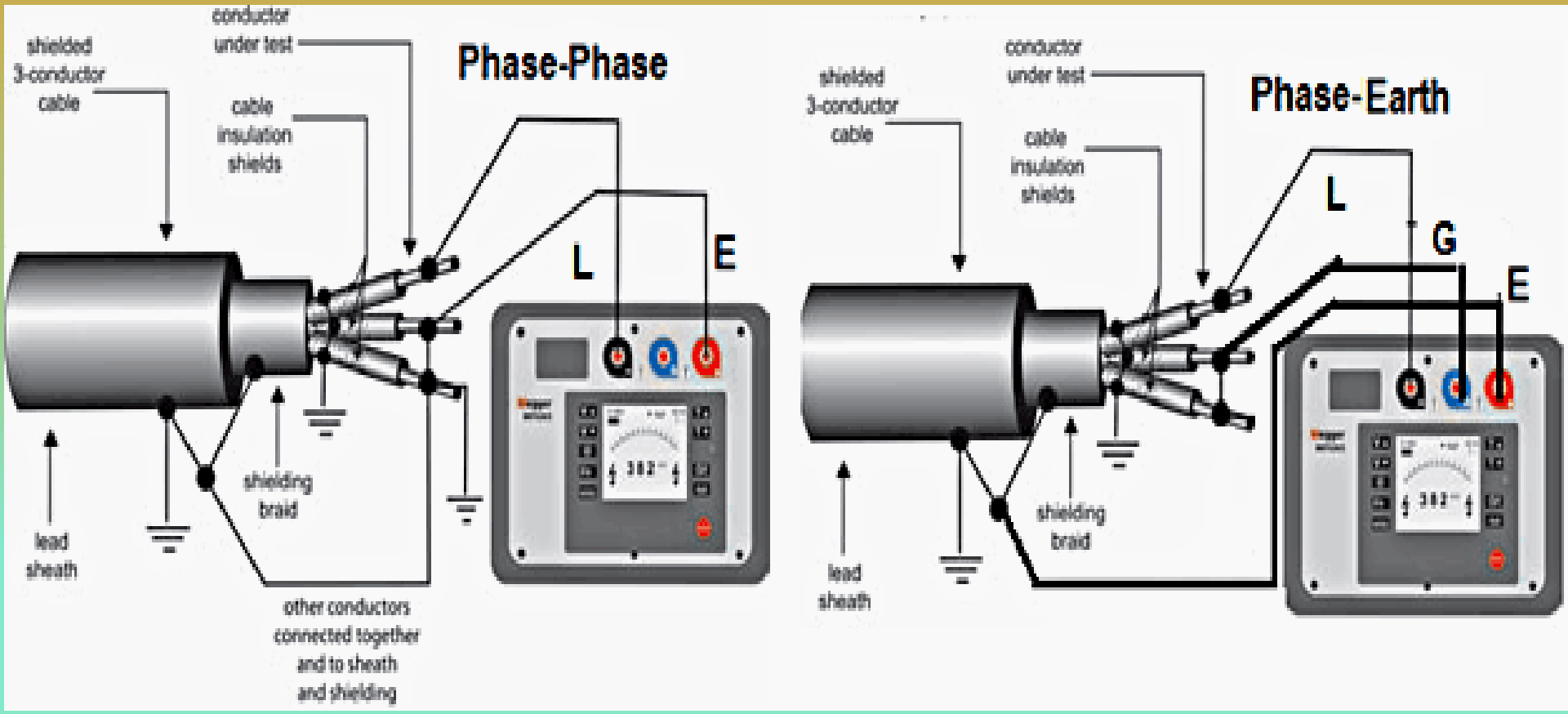
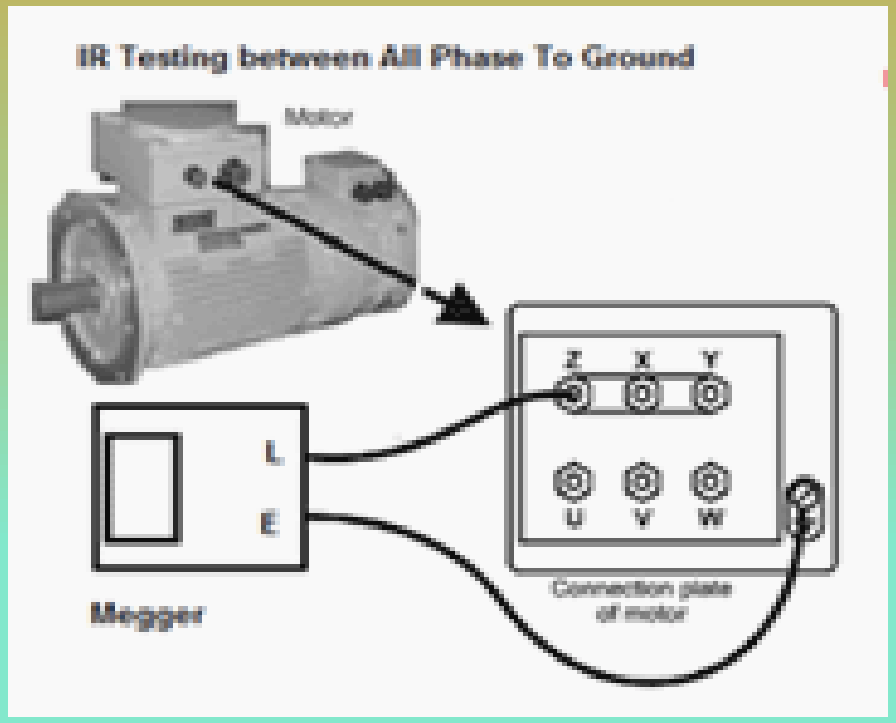
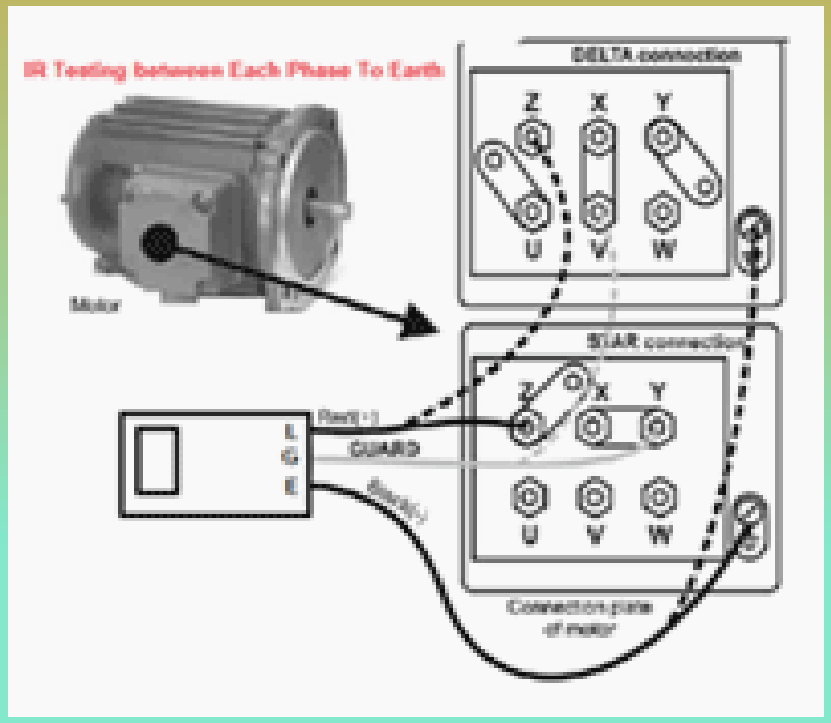

conductor under test
3 conductor cable
Insulation Tester
Lead sheah
Braid
G
L
E
Other conductors
connected together and
sheath

Fig. 4


Phase-Phase
shielded 3-conductor cable
conductor under test
cable insulation shields
L
E
shielding braid
lead sheath
other conductors connected together and to sheath and shielding
Phase-Earth
shielded 3-conductor cable
conductor under test
cable insulation shields
L
G
E
shielding braid
lead sheath

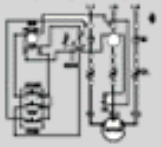

IR Testing between All Phase To Ground
Motor
Z
X
Y
L
E
U
V
W
Megger
Connection plate of motor


IR Testing between Each Phase To Earth
DELTA connection
Z
X
Y
U
V
W
Motor
STAR connection
L
G
E
GUARD
Connection plate of motor

Insulation Condition	60/30-sec Ratio	10/1-min Ratio (Polarization Index)
Dangerous	-	Less than 1
Questionable	1.0 to 1.25	1.0 to 2*
Good	1.4 to 1.6	2 to 4
Excellent	Above 1.6**	Above 4**

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-ˌlək-'trish-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

Safe Electricity®