Annex 4.30
Training Material for O&M of Electrical Equipment
in Spring 2018

O & M of Electrical Equipment
WSD 5231

Electrical Panel and Instrumentation Equipment

O & M of Mechanical and Electrical Equipment (Team)

Faculty Names	Contact Information
JICA Expert Takeo Maruyama (Electrical)	
Course Leader Mubasher Ahmad Cheema	
Module Leader Jawad Shahid	
Instructor Ihsan-ul-haque Javed	
Young Professional Tanveer Shahzad	

Course Dates

Modules	Dates	Themes
Module 1	March 26th to March 27th 2018	Electrical Control Panels
Module 2	March 28th to March 29th 2018	Generators & 5S
	March 30th 2018	Action Plan

3/22

Class Introduction

- ✓ What do we cover in this module?
- ✓ What to expect in this module?
- ✓ What is the role of electrical control panels in WASA operations?

4/22

Class Introduction

Your turn…

- ✓ How many of participants are from Electrical Engineering background?
- ✓ How many of you have experience in operating and maintaining electrical panels?
- ✓ Why interested in this module?
- ✓ What best skills do you bring to the team?

5/22

Agenda

- ✓ Introduction of Main Electrical Units
- ✓ Components of Electrical Control Panel
- ✓ General Design (Wiring Diagram)
- ✓ Motor Starters

6/22

Agenda

- ✓ Introduction to Motor
- ✓ Power factor correction
- ✓ Record Keeping
- ✓ Standard Operation Procedure (SOP)
- ✓ Energy Efficiency Analysis
- ✓ Preventive Maintenance

7/22

Class Evaluation Structure

Attendance	**30 %**
Exercise 1	**10%**
Exercise 2	**10%**
Exercise 3	**10%**
Exercise 4	**15%**
Action Plan	**25%**

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Lecture Goals

- **Distinguish types of panels in electrical systems of WASAs**
- **Understanding of basic sequence of the panel**
- **Testing and configuration of equipment**

9/22

Electrical Control Panel

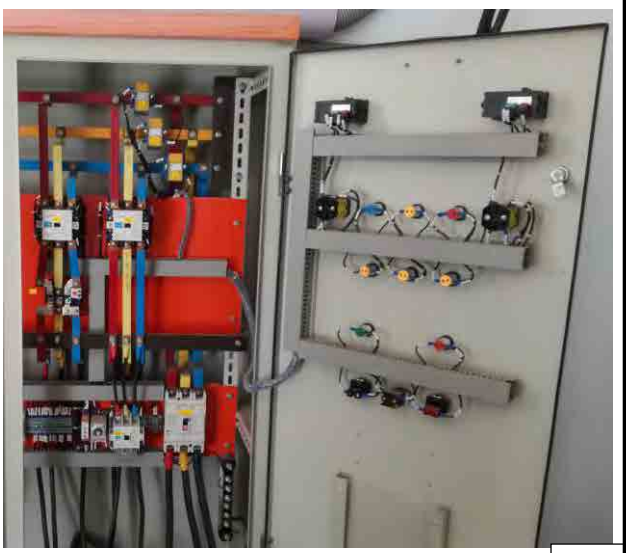
10/22

Introduction to Current & Voltage

11/22

Electric Control Panel

- ✓ Provides electrical energy with all necessary protections equipped within it.
- ✓ Used to ensure the controlled, protected and smooth transfer of electrical energy from one system to another.



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Major types of electrical control panel used in WASAs

1. Motor control unit (MCU)
2. Changeover switch
3. Power factor improvement (PFI) panel
4. Electrical distribution panel

13/22

Which one?

14/18

1.Motor control unit (MCU)

Motor Control Unit or simply MCU, are used to control and protect the electric motor. It is equipped with multiple relays, contactors, connections and indication lamps

Changeover Switch

Distribution Panel

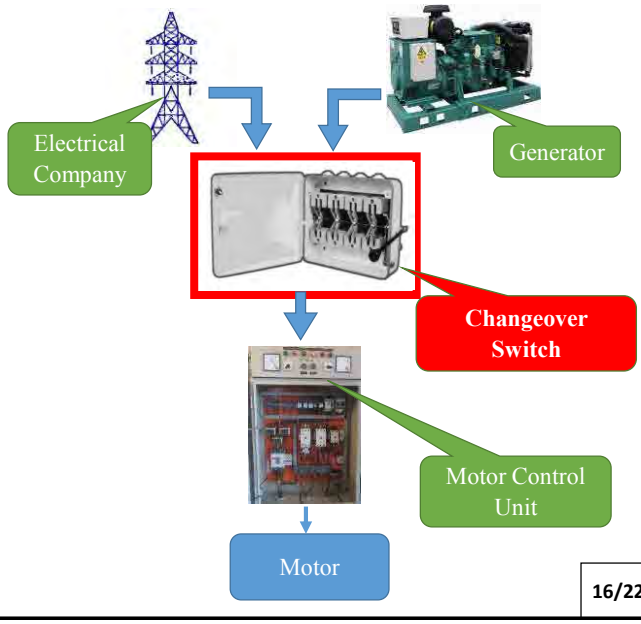
Motor control unit

Motor

15/22

2.Changeover switch

- ✓ Change over Panels are used to switch between primary and auxiliary power source. It is used in case of multiple connections from the electric supply company or generators



16/22

3.Power factor improvement panel

✓Power factor improvement panel is used to maintain the power factor to optimum value. It consists of a bank of capacitors connected together.

17/22

4.Electrical distribution panel

✓ It is basically a panel box, which receives electric supply from one or more sources and distributes it over the system through protections

18/22

Introduction to Panel Components

1/20

Goal

- **Understanding function of each component/ device in MCU**
- **Orientation to basic wiring connection along with wiring diagram**

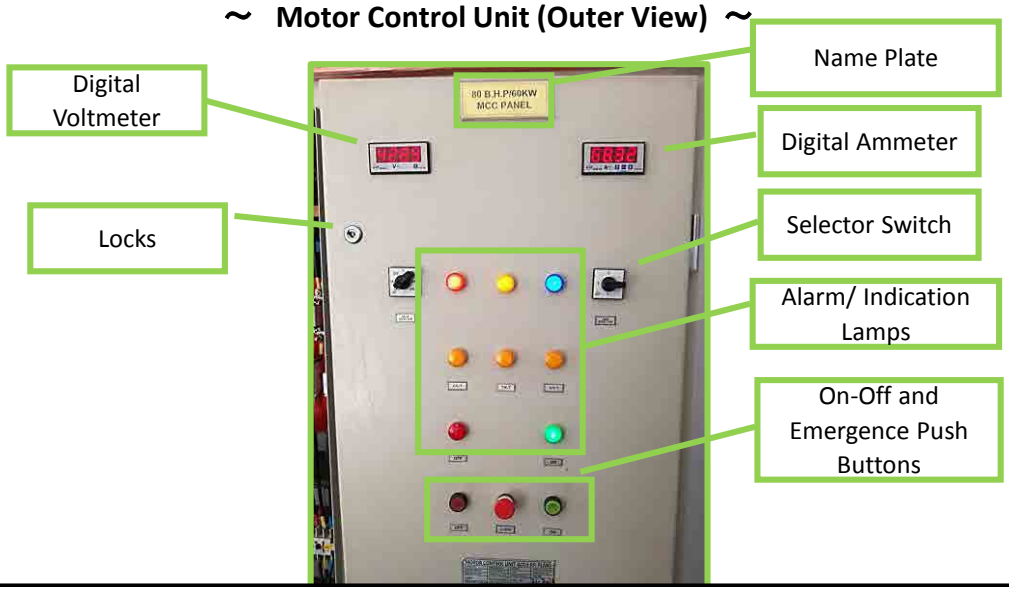
2/20

What are these?

3/20

Components of Electrical Control Panel

~ Motor Control Unit (Outer View) ~



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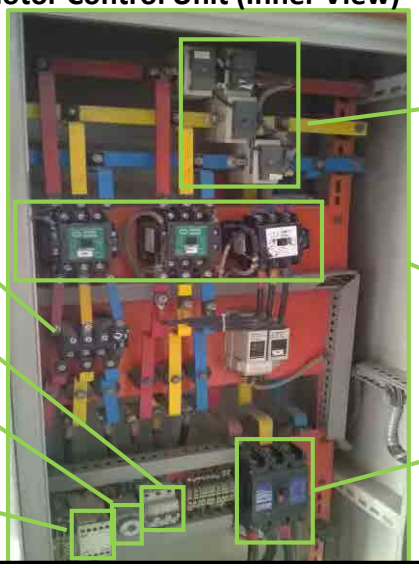
Components of Electrical Control Panel

~ Motor Control Unit (Inner View) ~



5/20

Selector Switches

- ✓ Used to select among each of the three phases to monitor currents and voltages on ampere and voltmeter.

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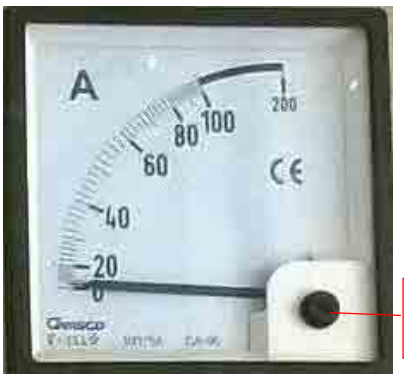
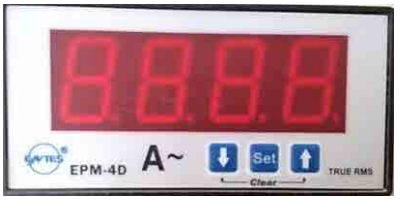
Ampere & Voltmeter meter

- ✓ Monitoring gauges for currents and voltages
- ✓ Digital and analog type Ampere and Volt meters are used by WASAs



Zero Adjustment



7/20

1. Circuit Breakers

Circuit breakers are switches that open/close electric circuits in normal and abnormal conditions specially in case of a short circuit.

8/20

2. Contactor

- ✓ A power contactor is typically used for “on / off” control of motors. A relay can be installed on the circuit for overload protection. Electromagnetic force works to “open /close” the contacts.

9/20

Protective Relays

- ✓ Protective relays detect electrical faults, isolate the faults from system and activate alarms is a faulty condition sensed

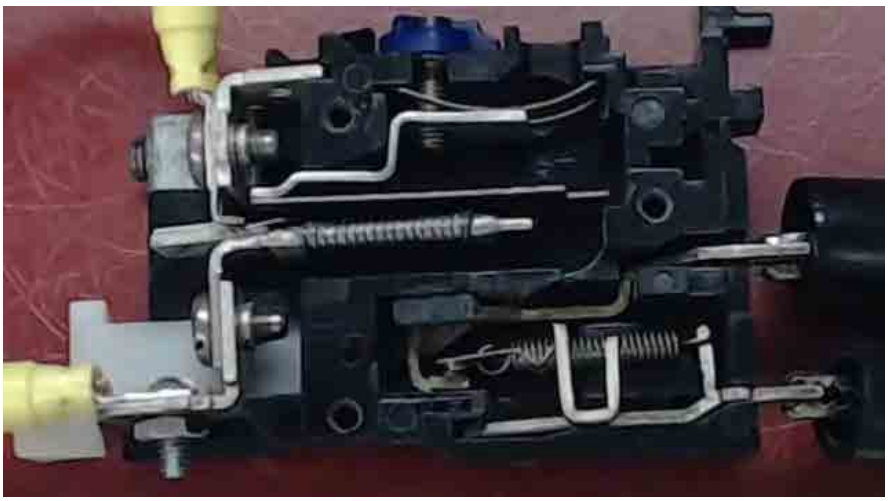
Thermal Relay

Under/Over Voltage Relay

Phase Failure Relay

10/20

Operation of thermal relay



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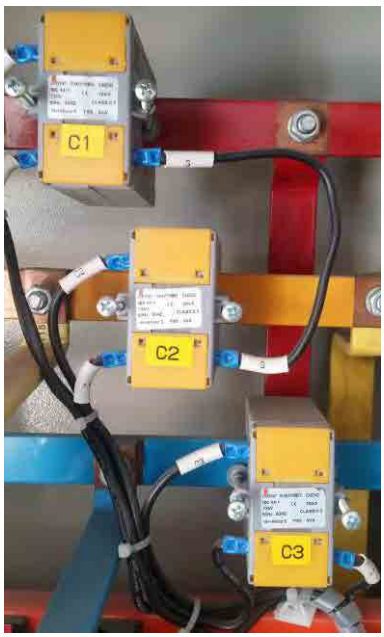
5. Current transformers (CT)

- ✓ CT's are used for stepping down current to be measured safely. It is also applied to protective relays



12/20

6. Timer

- ✓ Use to convert the motor connections from Star to Delta after specific time

13/20

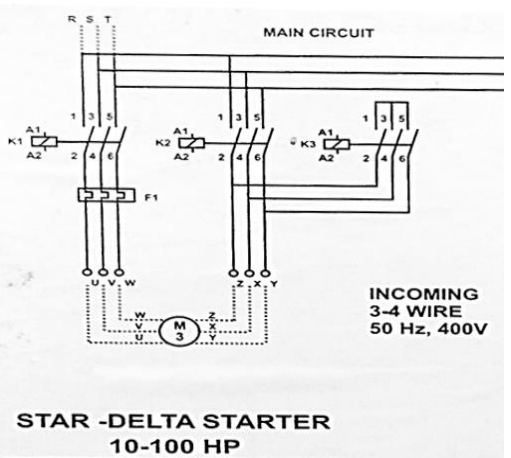
WIRING DIAGRAMS

14/20

Wiring Diagram

✓ Shows how the components are connected

✓ It should be always available at the site



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Basic Concept of Connection

WAPDA

3 phase, 400V

Basic Power Circuit for Motor in WASA

- Circuit Breaker
- Magnetic Contactor
- Over Load/Thermal Relay
- Over/Under Voltage Relay

Monitoring Device

- Voltage Meter
- Ampere Meter

Mechanical Protection from Short Circuit & Main Switch

Protection from abnormal voltage

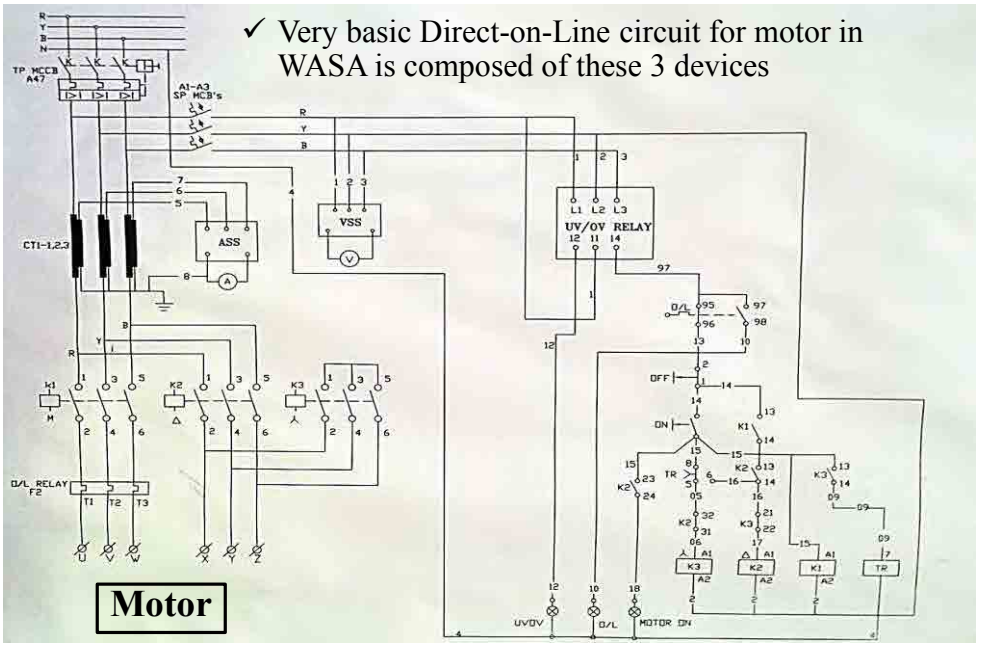
Auto/Manual Switch ON/OFF

Mechanical Protection from Over Current

Motor

16/20

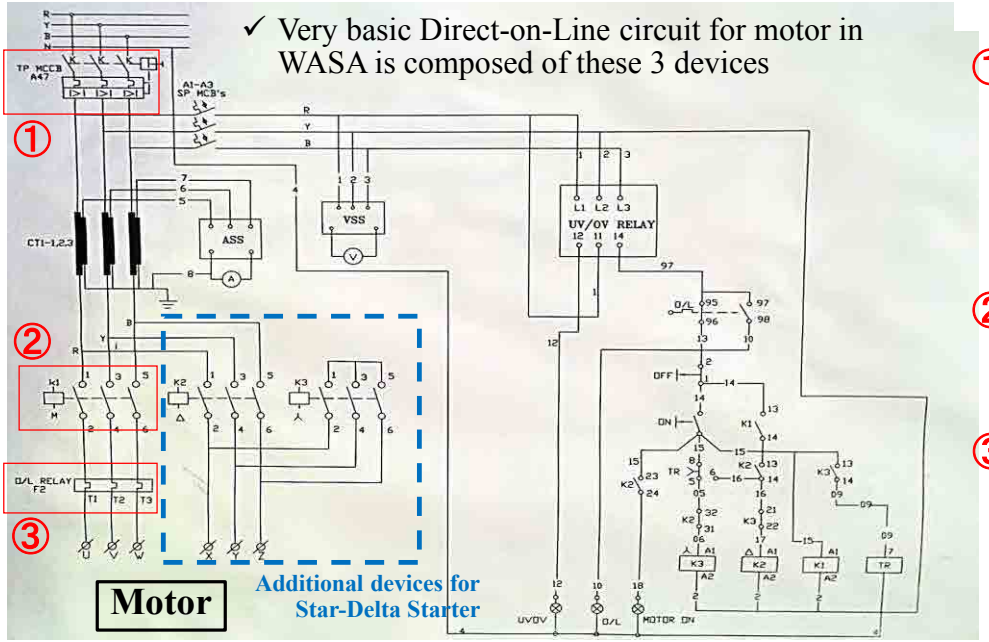
Main Power Circuit



✓ Very basic Direct-on-Line circuit for motor in WASA is composed of these 3 devices

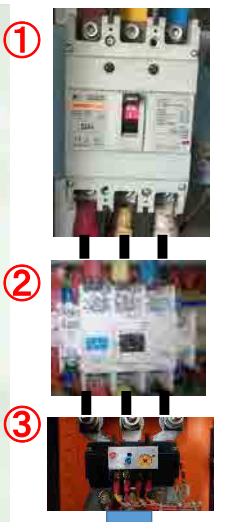
17/20

Main Power Circuit



✓ Very basic Direct-on-Line circuit for motor in WASA is composed of these 3 devices

Basic Power Circuit for Motor



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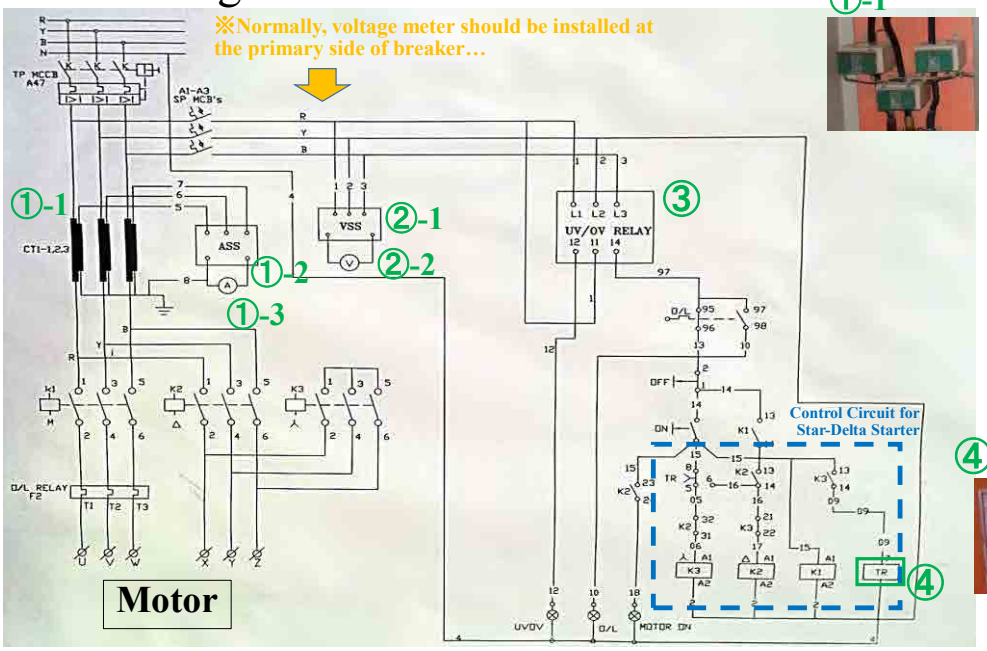
Monitoring and Control Circuit



19/20

ACTIVITY – 1

Complete the wiring diagram with the suitable components

20/20

Motor, Motor Starters & Power Factor Improvement

1/18

Goal of this Lecture

- **Gain common concept of motor, motor starter and its variety**
- **Understand the effect of Power Factor Improvement**

2/18

Motor Starters

- ✓ An extremely large current of about (5) five to (8) eight times the rated current flows at startup
- ✓ The power factor is extremely low at 0.2 at the start.
- ✓ Motor winding coil is subjected to thermal stress load. Voltage fluctuation occurs in the power system and its effect becomes more pronounced.
- ✓ The starting method of three-phase induction motor includes a method of restricting current at start as mentioned above, and other methods described below.

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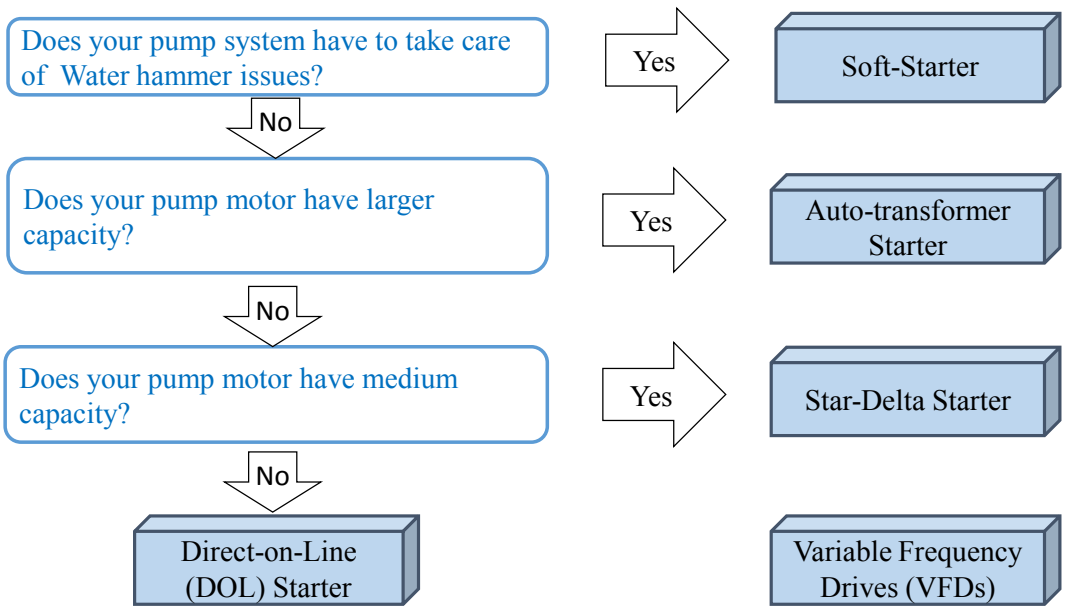
Selection of Motor Starter



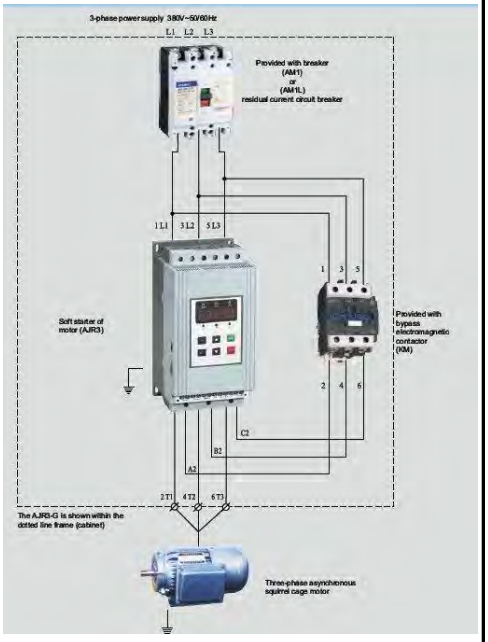
4/18

Soft Starter

Function:
Automatically starts/ stops the pump gradually slowly to avoid water hammer

Advantage:
Possible to make the stop slow as well as start operation

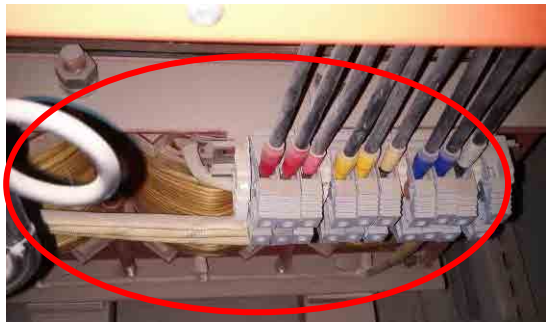
Disadvantage:
Electronic device shall be installed in a good environment so extra care is required



Single Line Diagram of Soft Starter

Auto-transformer Starter

Function:
Automatically controls voltages by changing transformer taps to reduce the starting current

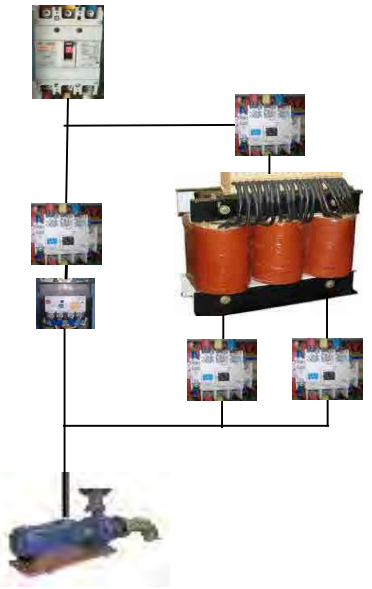


Transformer

Auto-transformer Starter

Advantage:
Less stress to the circuit due to flexible adjustment of voltage in the starting process

Disadvantage:
Expensive and wider space for installation is required



Single Line Diagram of Auto-transformer starter

7/18

Star-Delta Starter

Function:

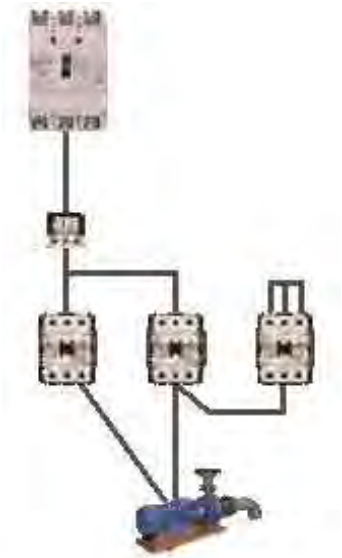
Arrangements of relays are so done that motor starts using star type connection and transferred to the delta type connection after few seconds

8/18

Star-Delta Starter

Advantage:
Easy, economical and common system to reduce starting current

Disadvantage:
Inrush current occurs in a moment of changing Star to delta
Six leads of the motor are required



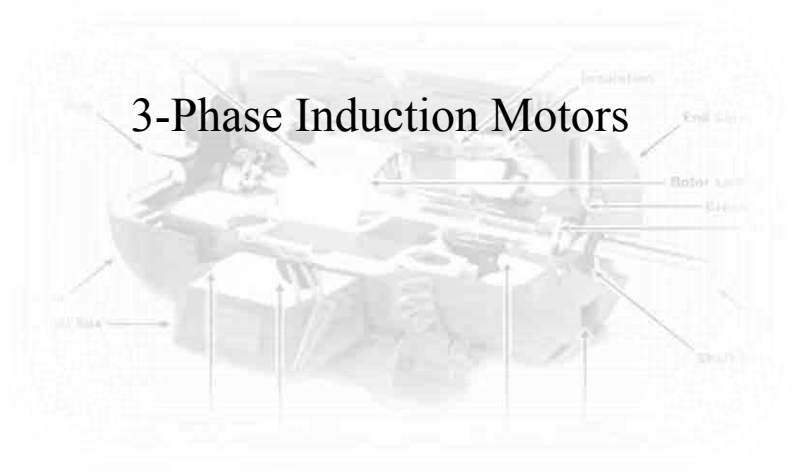
Single Line Diagram of Star-Delta Starter

9/18

Starting method	Type of equipment	Current input (mains load)	Run-up time	Heat build-up in motor during start-up	Mechanical loading	Hydraulic loading	Cost relation	Recommended motor designs	Comments
D. o. l.	Contactor (mechanical)	4–8 · I_N	Approx. 0.5–5 s	High	Very high	Very high	1	All	Mostly limited to ≤ 4 kW by energy supply companies
Star-delta	Contactor combination (mechanical)	$^1/_3$ of d. o. l. values	Approx. 3–10 s	High	Very high	Very high	1.5–3	All; canned motors and submersible motors subject to a major drop in speed during switchover	Usually stipulated for motors > 4 kW by energy supply companies
Reduced voltage	Autotransformer, mostly 70% tapping	0.49 times the d. o. l. values	Approx. 3–10 s	High	High	High	5–15	All	No currentless phase during switchover (gradually replaced by soft starters)
Soft start	Soft starter (power electronics)	Continuously variable; typically 3 · I_N	Approx. 10–20 s	High	Low	Low	5–15	All	Run-up and run-down continuously variable via ramps for each individual load application; no hydraulic surges
Frequency inverter	Frequency inverter (power electronics)	1 · I_N	0–60 s	Low	Low	Low	Approx. 30	All	Too expensive to use solely for run-up and run-down purposes; better suited for open- or closed-loop control

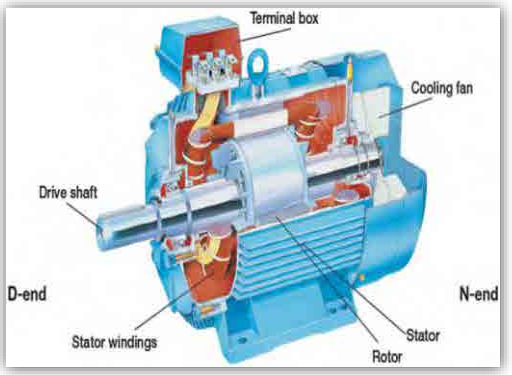
10/18

3-Phase Induction Motors



Introduction

- Electrical motor is an electromechanical device, which converts electrical energy to mechanical energy.
- Three-phase induction motors are the most common electrical motors used in the industry.

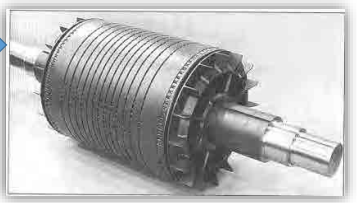


Basic Design and Construction

An induction motor has two main components:

1. (Stationary part) Stator

2. (Revolving part) Rotor



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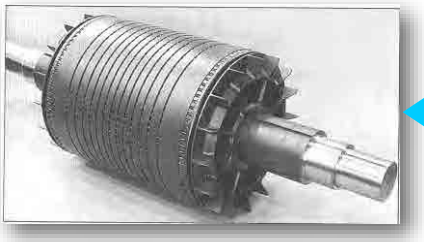
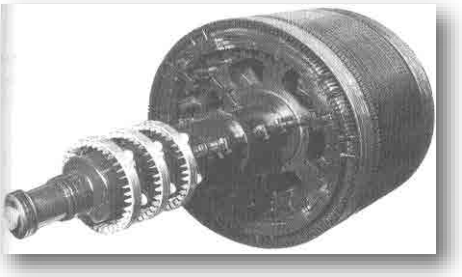
Basic Design and Construction

Rotor Types



Squirrel cage rotor

Slip ring rotor



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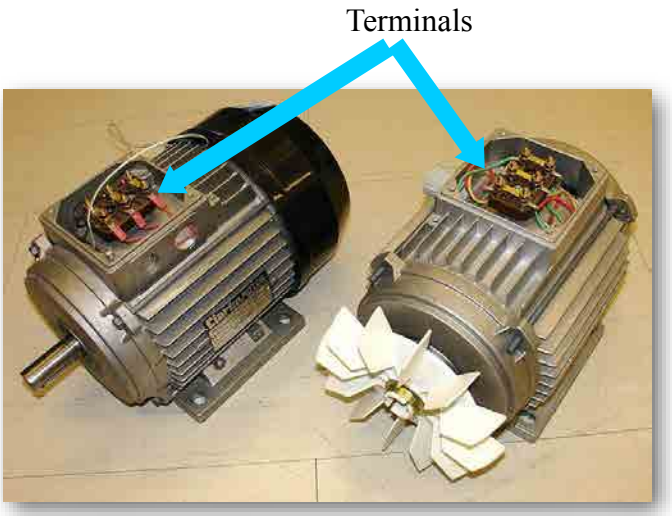
Basic Design and Construction



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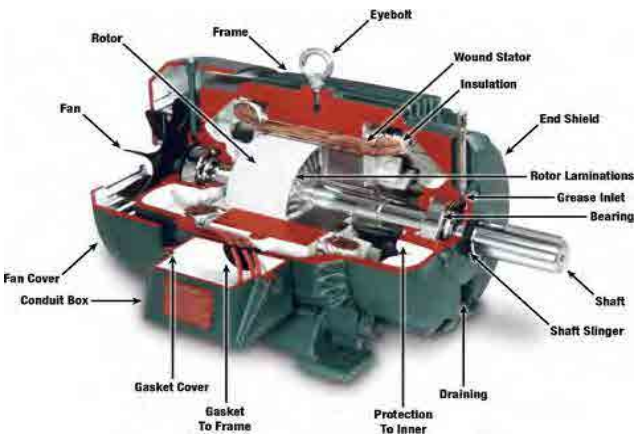
Basic Design and Construction

Section View



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Basic Design and Construction

17/18

Motor Burnout and Rewinding

Causes…

1. Fluctuation in phase voltages
2. Malfunctioning of protective relays
3. Manufacturing defects
4. Damage before or during installation
5. Improper installation
6. Misapplication (overload)

18/18

Motor Burnout and Rewinding

- Copper or aluminum wire should be used for rewinding the motor
- Preferably inside of the winding wire should be enameled copper wire (magnet wire)

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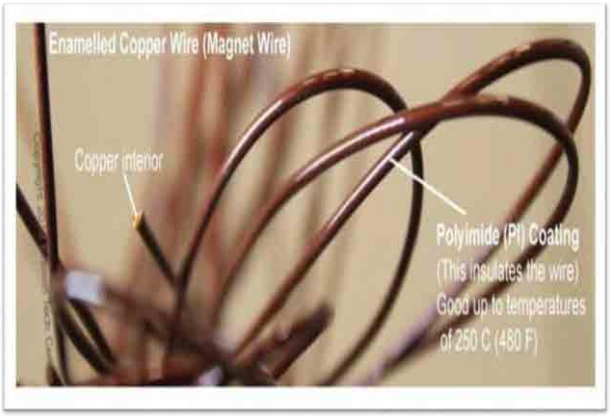
Motor Burnout and Rewinding

- After re-winding the assembly should be coated with risen and baked.
- Special care should be taken when inserting the rotor into the stator assembly.



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Troubleshooting

Sr. No.	Fault Indication	Causes
1.	Motor fails to start	Blown fuse or open circuit breaker
		Motor overload relay on starter tripped
		Low voltage or no voltage applied to the motor
		Defective motor windings
		Motor burnout
		Mechanical overload
2.	Excessive motor noise and vibration	Insufficient cooling/lubrication
		Overload
		Low phase voltage

Troubleshooting

Sr. No.	Fault Indication	Causes
3.	Motor overload protector continually trips	Excessive load
4.	Heated up bearings	Bent or sprung shaft Electrical Damage (Fluting)
5.	Worn bearings	Life span completed
		Foreign Matter (Dust and dirt)
		Electrical Damage (Fluting)
		Improper Bearing Lubrication
		Bearing Fatigue
		High Temperatures

Troubleshooting

Sr. No.	Fault Indication	Causes
6.	Mechanical locking in	Decreased air gap, jammed bearings or any foreign matter stuck
7.	Wrong rotation	Wrong sequence of phases
8.	Motor overheat	Overload
9.	Starter or circuit breaker not operating	Non availability of power or faulty relay
10.	Overheating of cable	Cable size inadequate

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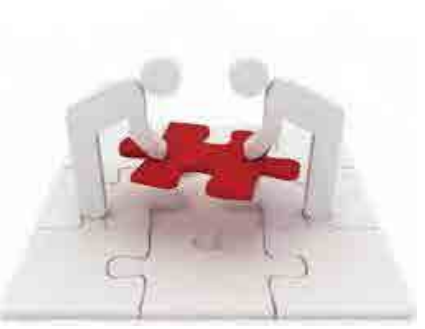
Wrap-up

Things to take home…

1. Motors drive your operations
2. Always do a root cause analysis
3. Repair is not preventive maintenance
4. Keep records, always !!!



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POWER FACTOR IMPROVEMENT

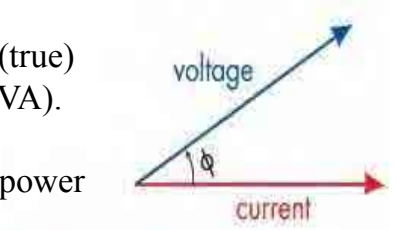
25/18

Power Factor Improvement

What is Power Factor?

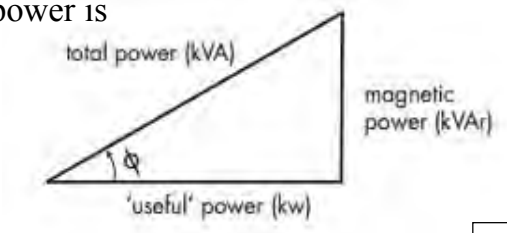
- ✓ Power factor is the ratio between the useful (true) power (kW) to the total (apparent) power (kVA).

Power factor (pf) = (Useful Power kW)/(Total power kVA) kW= kVI cosø



Phaser diagram of voltage and current

- ✓ It is a measure of how efficiently electrical power is converted into useful work output.
- ✓ The ideal power factor is unity.



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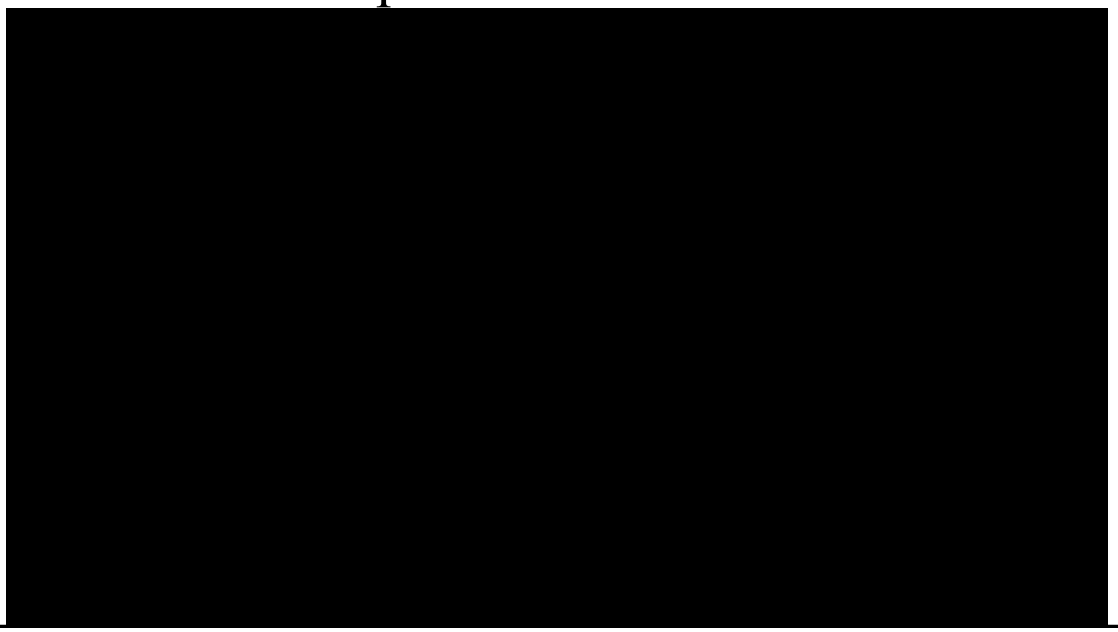
Power Factor Explained



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Power Factor Improvement

- ✓In case of Low Power factor, Improvement/ correction is required.
- ✓Correction is achieved by the addition of capacitors in parallel with the connected motor at the origin of the installation.

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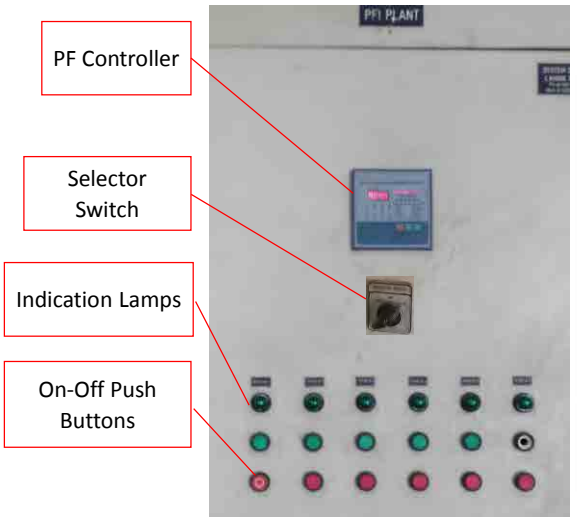
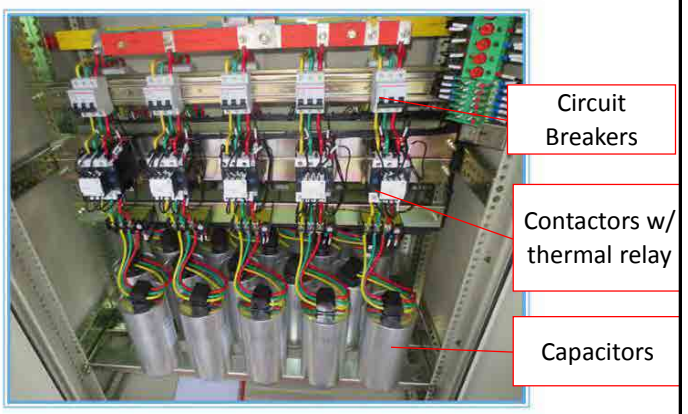
Power Factor Improvement Panel





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Auto Power Factor Controller

- ✓ Capacitors are selectively used to make the power factor of the system close to 1.00
- ✓ Actual power factor needs to be monitored by operators regularly
- ✓ Check the power factor mentioned on the electricity bill and do necessary action if required

30/18

Fuse

- ✓ Fuses avoid the flow of over currents by melting down itself
- ✓ They have to be replaced every time after use since they are not reusable like circuit breakers
- ✓ Regular inspection of its availability and maintaining enough quantity of spare parts in store is very important

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Power Factor Penalty

LAHORE ELECTRIC SUPPLY COMPANY - ELECTRICITY CONSUMER BILL(MDI)

http://www.lesco.gov.pk

CUSTOMER I.D.	ED@	BILL MONTH	READING DATE	ISSUE DATE	DUE DATE
1001380	1.0%	Jun 16	30 JUN 16	11 JUL 16	22 07 2016

REFERENCE No.	TARIFF	LOAD	OLD A/C No.
24 11351 9000901U	B3 (14)T	696.6	24135190009017

WEB GENERATED BILL
24 11351 9000901U

GST # 0305271800251

NAME & ADDRESS
XEN WASA
SEWRAGE PUMPING STATION KHOKHAR ROAD SHAD BAGH LA

SDO : 04237288866/03470011351
XEN : 04299250067/03470011350

Low power factor less than 0.9

SUB-DIVISION	KOT KHAWAJA SAEED
DIVISION	BAGHBANPURA
FEEDER	WASA

			P.F
0	0	85	.64

KWH	KWH METER READING			KVARH METER READING			MDI METER READING		METER STATUS
METER NO.	PREVIOUS	PRESENT	MF	PREVIOUS	PRESENT	MF	PRESENT	MF	
100329	8976.18	9135.87	2000	10742.39	10935.35	2000	.48	2000	
100329	2074.9	2106.09	2000	2467.34	2505.55	2000	.48	2000	

UNITS CONSUMED	(O)319380 (P)62380	(O)385920 (P)76420	CHARGED LOAD =	960

ENERGY/ FIXED CHARGES	METER/ SERVICE RENT	LPF PENALTY SEASON CHARGES	DEFERRED AMOUNT/	BILL ADJUSTMENT	EXTRA TAX	SALES TAX	FUEL PRICE ADJ PTV FEE	E-DUTY TR-SUR
3842058.00		189696	Low power factor penalty				-2470411.24	26967.78
364800				104150.80				1177218.00

N.J.S	G.S.T	INCOME TAX	I.TAX SURCHARGE	FURTHER TAX
38176	785335 *			92392

CURRENT BILL	6911781
ARREARS/AGE	2724756 / 1
XXXXXX P.M RELIEF TO INDUSTRY XXXXXX NET FPA	-1145280 -1325131.24
PAYABLE WITHIN DUE DATE	9636537
L.P. SURCHARGE	463082
PAYABLE AFTER DUE DATE	10099619

MONTH	MDI	KWH UNITS	BILL AMOUNT	PAYMENT
JUN15	960	463280	10105463	8228707
JUL15	1080	576340	11658711	10535124
AUG15	1160	448160	9172438	8503979
SEP15	1000	418820	7418497	7418497
OCT15	1200	420600	5671270	5671270
NOV15	920	418880	5829203	7263435
DEC15	1000	406600	5686585	5686585

32/18

Benefits of power factor correction

- ✓ Reduction of power consumption due to improved energy efficiency.
- ✓ Reduction of electricity bills.
- ✓ Extra kVA available from the existing supply.
- ✓ Reduction of I^2R losses in transformers and distribution equipment.
- ✓ Reduction of voltage drop in long cables.
- ✓ Extended equipment life.
- ✓ Reduced electrical burden on cables and electrical components.

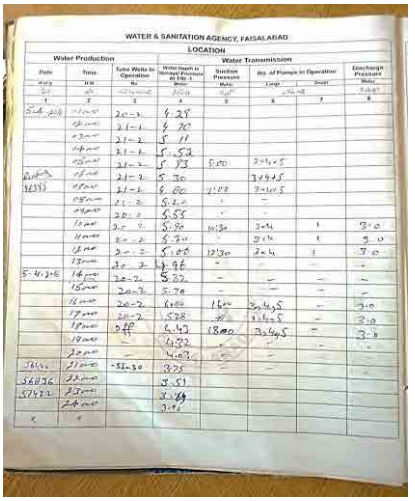
33/18

RECORD KEEPING

1/21

Record keeping

- Make balance of operation time of each load
- Predict & Prepare for future maintenance/procurement plan e.g. lubrication oil ,bearing, fuel, filters for generator
- Detect unsatisfied design, installation or repairing work by contractor



2/21

How to make daily operation record

Factors to note down during record keeping (Pumps):

- ✓ Pump operating time (Hrs.)
- ✓ Flow
- ✓ Pressure
- ✓ Power factor
- ✓ Voltage
- ✓ Ampere

3/21

STANDARD OPERATING PROCEDURE (SOP)

4/21

Standard Operating Procedure (SOP)

- ✓Before turning on the motor, values of all protective relays must be checked once a day
- ✓Following format and slides are showing some of the general ideas for O&M and errors in operation in WASA's Motor Control Unit:

Check List of Standard Operation Procedure for Electrical Facility

Approved by :

Inspected by :

Motor Specification: Rated Capacity (kW/HP) _____

Rated Voltage (V) _____Rated Current(A) _____

Efficiency____Power Factor_____RPM_____

Evaluation Criteria

✓: Good ×: No care at all or need to be newly installed

Δ: Need to be improved —: Not available to be checked

Sr. No.	Site/Pump Name	Inspection Date	Inspection Items for Electrical Panel Condition															
			Document			Visual (Outside)						Visual (Inside)				Operation		
			Operation Record	Drawings	Vender Manual	Identification of Lamp/Switch	Status/ Fault Indication Lamps	Ampere Meter	Voltage Meter	Status Selector Switch		Cleanliness	Intrusion Path	Bypass-Circuit	Neatness of cabling	How to operate changeover switch	Frequency of Start/Stop	
			Compare with the sample	Pump installation , electrical line diagram	Pump/ Panel devices	all lamps /switches have name tag	all lamps are visibly bright enough	Proper functioning and zero adjustment	Proper functioning and zero adjustment	Ampere	Voltage	No dust, sand, spider's nest, insect, small animals	No hole/ crack to let foreign matters come in	No bypass / burnt mark		Turn off by breaker or switch first.	Maximum 2-3 times/ hour	
1																		

5/20

Check List for Standard Operation Procedure

Check List of Standard Operation Procedure for Electrical Facility

Approved by : SDO

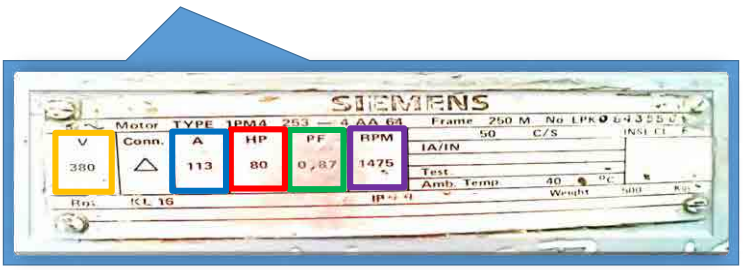
Inspected by : Sub Engineer (Electrical)

Motor Specification: Rated Capacity (kW/HP) 80 HP x 0.746 = 60KW

Rated Voltage (V) 380 Rated Current(A) 113

Efficiency — Power Factor 0.87 RPM 1475

Sr. No.	Site/Pump Name	Inspection Date
1	Tube well 103	12-DEC-16



6/20

Check List for Standard Operation Procedure

Check List of Standard Operation Procedure for Electrical Facility

Approved by :

Inspected by :

Motor Specification: Rated Capacity (kW/HP) _____

Rated Voltage (V) _____Rated Current(A) _____

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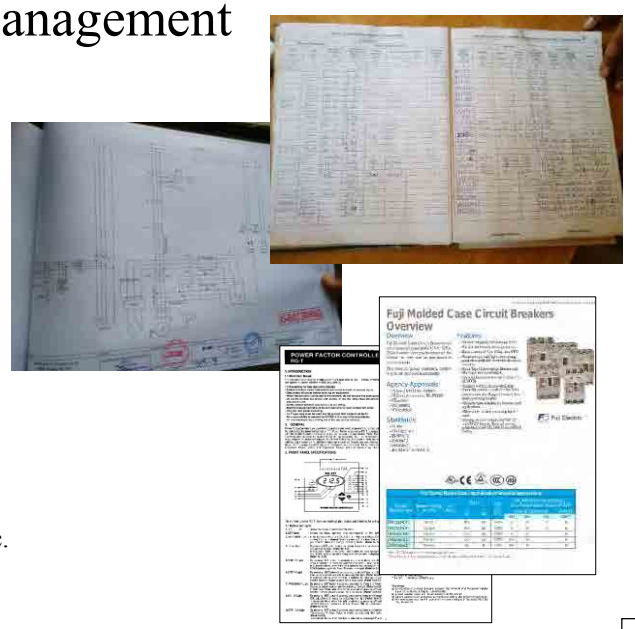
1																	
2																	
3																	

7/20

Basic Documentation Management

- ✓ Operation Record
  - Time of Start/Stop, Total Operation
  - Maintenance/Replacement Record
  - Trouble Record, Any Remarks etc.
- ✓ Drawings
  - Shop-Drawings, As-Built Drawings (Equipment and Installation Drawings)
  - Electrical Wiring Diagram etc.
- ✓ Vender Manuals
  - Installation Manuals
  - Operation & Maintenance Manuals
  - Device Catalogs & Manuals etc.



8/20

Check List for Standard Operation Procedure

Check List of Standard Operation Procedure for Electrical Facility

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Inspected by :

Motor Specification: Rated Capacity (kW/HP) _____

Rated Voltage (V) _____Rated Current(A) _____

Efficiency_____Power Factor_____RPM_____

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1																	
2																	
3																	

Comparison of the Panel Conditions

NEED TO BE IMPROVED

No name plate or information about panel

Malfunction or non-zero adjustment meters

No/bypassing Protective relays

Energized parts are revealed without any caution and protection

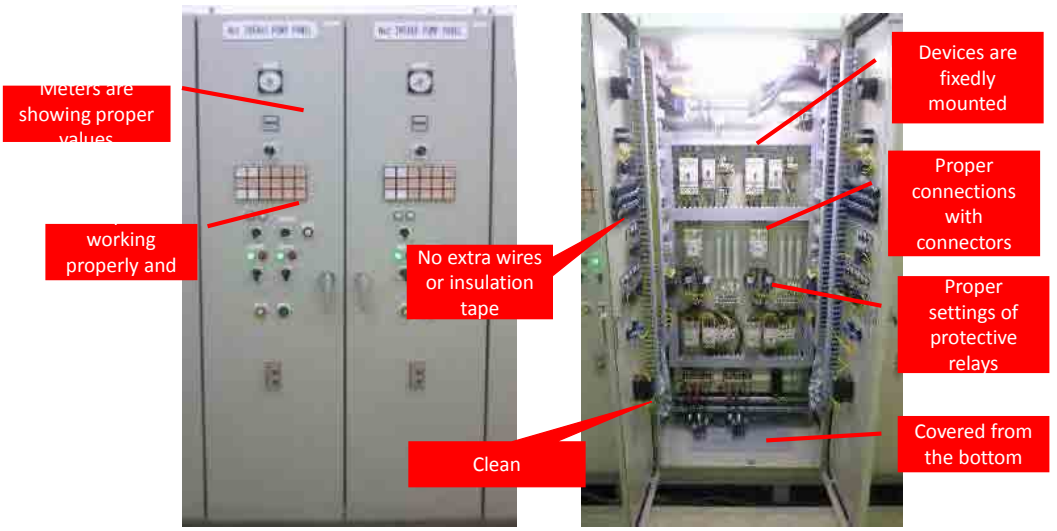
No Proper connections

Large uncovered hole letting small unwelcome friends come in

Dusty

Comparison of the Panel Conditions

IDEAL CONDITION OF A PANEL



11/20

Check List for Standard Operation Procedure

Check List of Standard Operation Procedure for Electrical Facility

Approved by :

Inspected by :

Motor Specification: Rated Capacity (kW/HP) _____

Rated Voltage (V) _____Rated Current(A) _____

Efficiency_____Power Factor_____RPM_____

Evaluation Criteria

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1																		
2																		
3																		

12/20

Difference between…

Disconnection Switch

- ✓ **Offline** operation
- ✓ Isolate system
- ✓ Disconnecting system for safety purpose

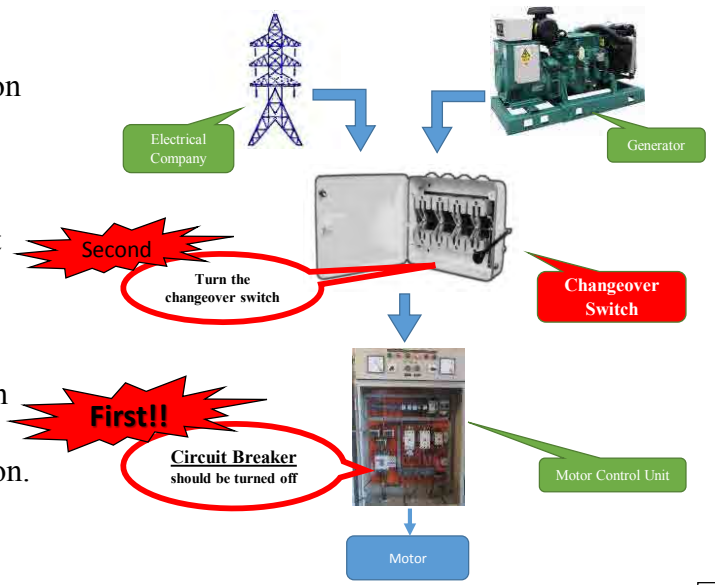
Circuit breakers

- ✓ **Online** operation
- ✓ Capable of making, carrying and breaking currents under normal conditions
- ✓ Short-circuit switching

13/20

- How to operate changeover switch -

- ✓ Don't directly open/turn the changeover switch during operation of load
- ✓ Changeover switch does not have function to break the active circuit so you have to turn off the circuit breaker/magnetic contactor first!
- ✓ The terminal of changeover switch would spark and get burnt if you operate it in the energized condition.



14/20

- Frequency of Motors' Start/Stop -

- ✓ Each motor has a condition of number of start to prevent burnout and damage to insulation material
- ✓ There are two types of conditions to be confirmed with manufacturer, "Hot-start" and "Cold-start". Number of Hot-start should be more limited.
- ✓ Frequent and immediate ON/OFF operation (equivalent to Hot-start) could cause stress to the motor and shorten its life time.

15/20

PREVENTIVE MAINTENANCE

Goal of this Lecture

- Understand importance of Preventive Maintenance
- Get familiar with the required equipment and tools for Preventive Maintenance on MCU

Circuit Breaker Failure

- **WHY> Due to Carbon deposits on it terminals**
- **WHY> Due to fatigue (life cycle completed)**
- **WHY> Was periodic inspection conducted?**
- **WHY> YES! Wear and tear was observed and replacement was recommended**
- **WHY> The specific model was out of inventory**

3/20

Preventative maintenance

- What is definition of electrical preventative maintenance?

✓The scheduled inspection, testing and maintenance of critical electrical components to prevent failure and enhance equipment life cycle.

4/20

Preventative maintenance

Scheduled!!!

1) Start with a plan
2) Depending on the time of maintenance and the environment, the frequency can vary
3) Be proactive rather than reactive

5/20

Preventative maintenance

The cost of ignoring maintenance

A well administrated preventative maintenance program :

- Reduces accidents
- Saves lives
- Minimizes costly breakdowns and unplanned outages

Impending troubles can be identified and solutions applied, before they become major problems requiring more expensive, time consuming solutions.

6/20

Inspection Tools

1. Voltage Tester

2. Screw Drivers Set

3.Pliers

4. Adjustable Wench

5.Ratchet Screwdriver

6. Ratchet Socket Wrench Set

Analysis and Testing Equipment

9/20

Sample Format for Preventive Maintenance

Preventive Maintenance Sheet for Electrical Facility

Sub Division :		**Motor Specification**			**Rated Capacity (kW/HP)**	
Site Name:		**Rated Voltage**	**Rated Ampere**	**Efficiency**	**Power Factor**	**RPM**
Equipment Name:		**(V)**	**(A)**	-	-	
Date						
Inspected By						
Weather						
Bolt Tightening						
Insulation Resistance (MΩ)	U1-E	U2-E				
	V1-E	V2-E				
	W1-E	W2-E				
	U1-V1	U2-V2				
	V1-W1	V2-W2				
	W1-U1	W2-U2				

① Test in OFF Condition

② Test in Running Condition

Voltage by Clamp Meter (V)	RY					
	YB					
	BR					
Ampere by Clamp Meter (A)	R					
	Y					
	B					
Power Factor						
Vibration	Upper Bearing	Lower Bearing				
Revolution Per Minute (RPM)						
Temperature	Upper Bearing	Lower Bearing				
	Shaft					
Reference for Insulation Resistance Value:				Good → more than 1.0MΩ		
Need to Adjust, Clean,Care → 1.0MΩ ~ 0.4M Need to repair immediately →less than 0.4MΩ						
- Remarks -						

10/20

What is “Insulation Resistance” ?

- Insulation resistance is the value showing if there is electrical leakage or not with the measured equipment.
- Insulation resistance tester is a tool to check how properly the system/equipment is insulated.
- If the value show less than 1 MΩ, need to be cared. If less than 0.4 MΩ (i.e. for 400V), detect the faulty parts and replace them immediately.
- It is necessary to check not only one time value but also the trend and comparison with the previous value.

Insulation Resistance Tester

11/20

Appendix

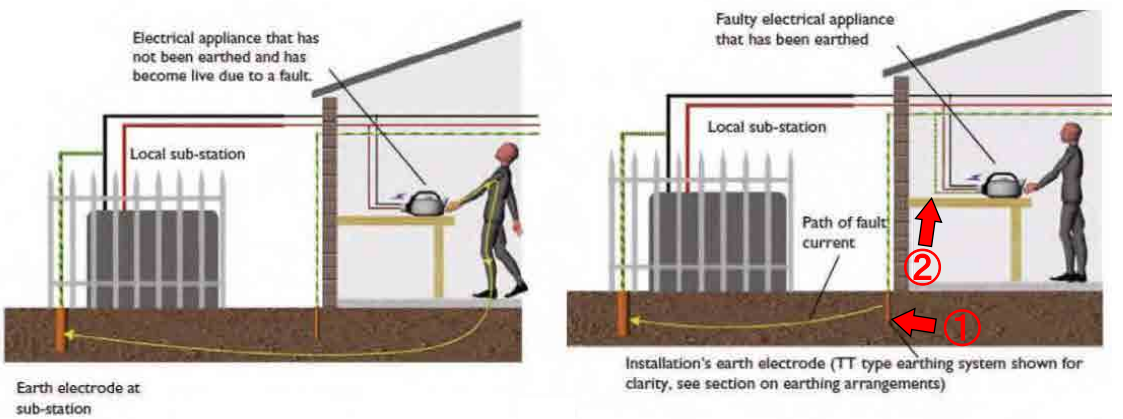
12/20

Electrical Leakage

- Electrical leakage is dangerous for not only machinery but also humans
- Any electrical leakage has to be found in the early stage and remedied properly for the system safety and efficiency

Current	Effect to Human
1mA	Feeling
5mA	Feeling keenly
10mA	Unbearable feeling of pain
20mA	The contraction of muscles and The victim cannot let go of the circuit.
50mA	Danger, Extreme pain
100mA	Fatal injury

Electrical Leakage - Importance of Grounding -



In order to avoid any trouble caused by electrical leakage, it is very important to
① Install an earth electrode giving sufficiently low resistance and
② Properly connect it with casing of electrical facility

Reference: https://www.linkedin.com/pulse/20141104174845-23740981-earthing-system-how-save-are-you-from-electric-shocks

Action Plan

What is an action plan?

An action plan is a document that lists…

- ✓ what steps must be taken in order to achieve a specific goal

The purpose of an action plan…

- ✓ is to clarify what resources are required to reach the goal
- ✓ formulate a timeline for when specific tasks need to be completed

Action Plan Template

ALJAZARI ACADEMY

POST TRAINING ACTION PLAN

Training Title: WSD 5231, Module2, Electrical Control Panels Date of Training: 25-11-2016

Name of Participant: Mubasher Ahmad Cheema

Name of Organization: Al-Jazari Academy

Action Plan Template

Please list three important concepts, ideas, or skills which you plan to take from the training and implement in your work (please focus on SOP, Record Keeping and Preventive maintenance)

1. Record facility operational hours
2. Implement equipment maintenance plan
3. Implement standard operating procedures

Action Plan Template

Please identify a specific plan (in sequential steps) that you will implement upon your return to WASA.

Sr. No.	**Action Item** (maintenance plan)	**Due Date**
1	Ensure record keeping templates are available on site both hard copies and electronic copies	Dec 15th, 2016
2	Ensure all equipment manuals and instructions are available on site	Dec. 15th, 2016
3	Ensure all required inspection/testing tools and **PPE** are available on site	Dec. 15th, 2016
4	Prepare a list/quantity of crucial items (replacement parts) required on site	Dec. 15th, 2016
5	Assign trained personals to routinely check what items are due for completion as per maintenance checklist	Dec. 20th, 2016
6	Establish a weekly maintenance plan implementation review meeting	Dec. 23th, 2016

Action Plan Template

Please identify required resources to implement this plan.

1. Trained personal
2. Testing and inspection tools
3. Data recording accessories (log books, computer)
4. Spare parts
5. Storage facility
6. Office space

Please identify any barriers or hindrances to the implement this plan.

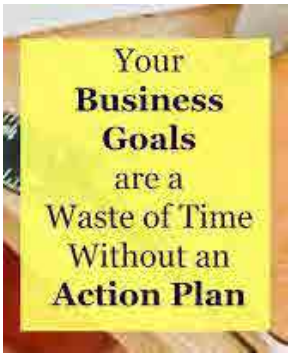
1. **Implementation approval**
2. **Management support**
3. **Required tools**

Action Plan Template

Other Comments or Notes:

Need extra manpower to successfully implement and sustain the maintenance plan.

What if not Action Plan?



OJT Implementation Procedure

~ Please let us work with you ~

OJT Implementation Procedure

1. Immediately perform what you have learnt **at one site in a few days**
2. **Share the result with instructor**, then correct it if necessary
3. Select several sites to perform and **please inform to the instructor**
4. Try to repeat the work at the sites on your own **along with OJT**
5. **Let the instructor's team visit your sites** and share the progress

Dec 2016 – Feb 2017

Implementation Procedure

Let us know where you will perform and who are involved

WASA :			Division :		

Administrative Information						
Site No.	Location		Name of the Persons in Charge			
	Sub Division	Site Name	XEN	SDO	Sub Engineer	Operator
1.						

Implementation Procedure

Sample

WASA : Lahore			Division : Nishtar Town		

Administrative Information						
Site No.	Location		Name of the Persons in Charge			
	Sub Division	Site Name	XEN	SDO	Sub Engineer	Operator
1.	Green Town	Tube well, 4-D1	Ishfaq Tirmazi	Shammas Ayoub	Muhammad Imran	Murtaza

Implementation Procedure

Let us know when you will perform and who is your Boss !

Approved by	
Prepared by	

Contents of Activity	2016				2017					
	Nov		Dec		Jan		Feb		Mar	
	Planning Date	Completed	Planning Date	Completed	Planning Date	Completed	Planning Date	Completed	Planning Date	Completed
Daily Operation Record										
SOP Check List										
Preventive Maintenance Record										

Implementation Procedure

Sample

Approved by	Shakeel Kashmiri – Director
Prepared by	Shammas Ayoub – SDO Green Town

Contents of Activity	2016				2017					
	Nov		Dec		Jan		Feb		Mar	
	Planning Date	Completed	Planning Date	Completed	Planning Date	Completed	Planning Date	Completed	Planning Date	Completed
Daily Operation Record	Nov 29				Jan 31				Mar 8	
SOP Check List										
Preventive Maintenance Record										

Implementation Procedure

We are very much Expecting…

Approved by	Shakeel Kashmiri – Director
Prepared by	Shammas Ayoub – SDO Green Town

Contents of Activity	2016				2017					
	Nov		Dec		Jan		Feb		Mar	
	Planning Date	Completed	Planning Date	Completed	Planning Date	Completed	Planning Date	Completed	Planning Date	Completed
Daily Operation Record	Nov 29	○			Jan 31	○			Mar 8	○
SOP Check List		○				○				○
Preventive Maintenance Record		○				○				○

It would be greater if you write down

Instructor's team will make a plan to visit the site referring to your schedule!!

WASA : Lahore Division : Nishter Town

Administrative Information							Contents of Activity	2016				2017					
								Nov		Dec		Jan		Feb		Mar	
Site No.	Location		Name of the Persons in Charge					Planning Date	Completed	Planning Date	Completed	Planning Date	Completed	Planning Date	Completed	Planning Date	Completed
	Sub Division	Site Name	XEN	SDO	Sub Engineer	Operator											
1.	Green Town	Tube well, 4-D1	Ishfaq Tirmazi	Shammas Ayoub	Muhammad Imran	Murtaza	Daily Operation Record	Nov 29				Jan 31				Mar 8	
							SOP Check List										
							Preventive Maintenance Record										
2.	Green Town	Pump#1, Disposal Station, Ameer Chowk	Ishfaq Tirmazi	Shammas Ayoub	Muhammad Imran	Salman	Daily Operation Record										
							SOP Check List			Dec 13				Dec 14			
							Preventive Maintenance Record										
3.	Green Town	Pump#2, Disposal Station, Ameer Chowk	Ishfaq Tirmazi	Shammas Ayoub	Muhammad Imran	Salman	Daily Operation Record										
							SOP Check List			Dec 27				Dec 28			
							Preventive Maintenance Record										
4.	Suginami	Koenji Tube Well	Mubasher	Jawad	Akira	Zain	Daily Operation Record										
							SOP Check List					Jan 17				Mar 22	
							Preventive Maintenance Record										

Ideal Goal

														Approved by	Shakeel Kashmiri – Director				
WASA : Lahore				Division : Nishtar Town										Prepared by	Shammas Ayoub – SDO Green Town				

Administrative Information							Contents of Activity	2016				2017					
								Nov		Dec		Jan		Feb		Mar	
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							SOP Check List		O				O				O
							Preventive Maintenance Record		O				O				O
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							SOP Check List				O				O		
							Preventive Maintenance Record				O				O		
3.	Green Town	Pump#2, Disposal Station, Ameer Chowk	Ishfaq Tirmazi	Shammas Ayoub	Muhammad Imran	Salman	Daily Operation Record			Dec 27	O			Dec 28	O		
							SOP Check List				O				O		
							Preventive Maintenance Record				O				O		
4.	Suginami	Koenji Tube Well	Mubasher	Jawad	Akira	Zain	Daily Operation Record					Jan 17	O			Mar 22	O
							SOP Check List						O				O
							Preventive Maintenance Record						O				O

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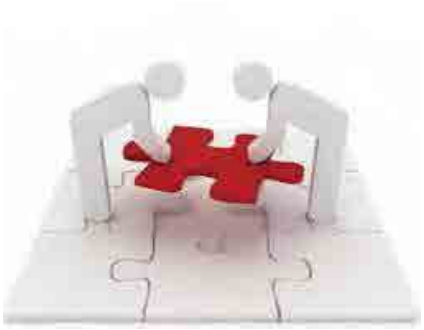
5. **Let the instructor's team visit your sites** and share the progress

Wrap-up

- Things to take home…
- Motors drive your Operation.
- Always do a root cause analysis
- Repair is not preventive maintenance
- Keep records, always !!!
- **Take an action, Immediately!!!!!!!!!**



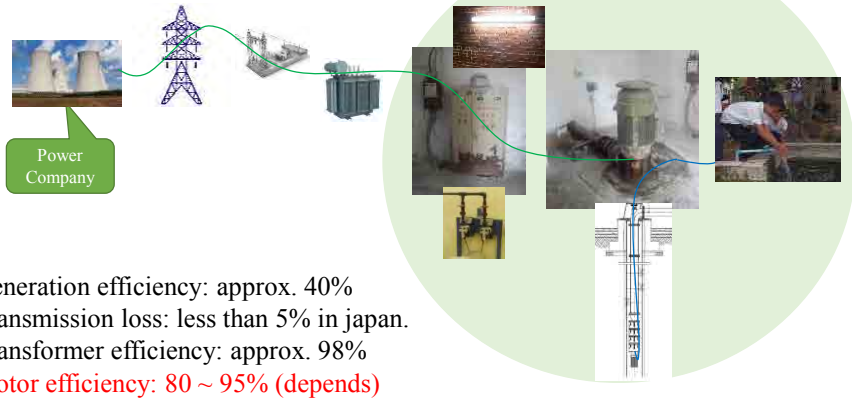
We will look forward to your response.

ELECTRICITY to WATER

Energy use of tube well pump system

ELECTRICITY to WATER

- **How we get power supply to Pump.**



Generation efficiency: approx. 40%
Transmission loss: less than 5% in japan.
Transformer efficiency: approx. 98%
Motor efficiency: 80 ~ 95% (depends)
Pump efficiency: 70 ~ 80% (depends)

WHAT IS ENERGY AUDIT ACTIVITY

BASIC KNOWLEDGE for ENERGY AUDIT

Concept of

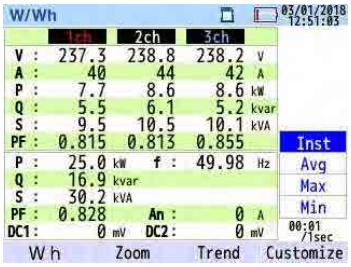
- Electrical Capacity (kW)
- Pump Efficiency
- Principle of measurement
- Evaluation for Pump station

Equipment Required

- Power analyser
- Ultrasonic Flowmeter
- Pressure Gauge
- Water level meter
- Tachometer
- Thermometer
- Vibration meter

Power Analyzer:

- Values of Voltages, Currents, Power Factor and Motor Input Power (P_{mi}) is collected using power analyzer.



BASIC KNOWLEDGE for ENERGY AUDIT

✓Turbine Meters

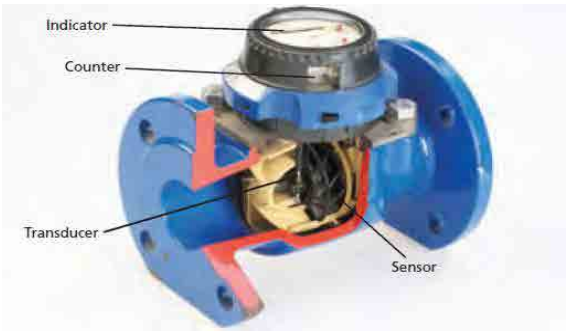
✓Ultra Sonic Flow Meters

✓Electromagnetic Meters

Turbine meter

✓These meters have a rotating element that turns with the flow of water.

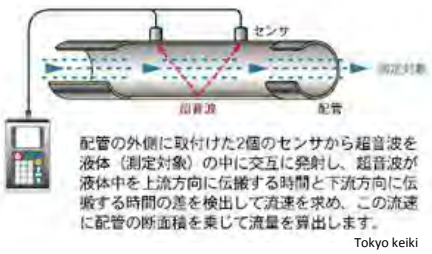
✓Volume of water is measured by the number of revolutions by the rotor.



Ultrasonic meters

✓Sending sound waves from 2 sensor (transmitter) diagonally across the flow of water in the pipe.

✓The time difference between 2 direction to be converted to flow velocity.



(there is Doppler shift method, too)

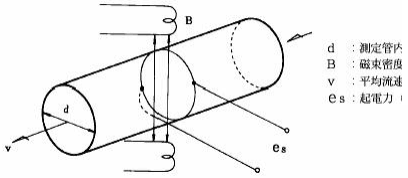
Ultrasonic flowmeter (time transit)

9

Electromagnetic meter

✓Induce magnetic field in the bore by coils outside of the flow channel. When water flows the magnetic field, electromotive force (Voltage) is induced.

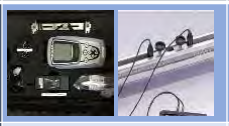
✓The electromotive force will be converted proportionally to velocity and hence the flow rate.



Electromagnetic flowmeter

10

BASIC KNOWLEDGE for ENERGY AUDIT

	Ultra Sonic	Electromagnetic	Turbine
Appearance			
Accuracy	lower than Electromagnetic in small flow rate	High	lower than others in small flow rate
Installation condition (D:pipe dia)	Before meter:10D After meter:5D	Before meter:5D After meter:2D	Before meter:10D After meter:5D
Pressure loss	No pressure loss	Almost no pressure loss	Pressure loss due to around Impeller
Telecommunications	Available	Available	Available
Initial Cost	Expensive	Expensive	Inexpensive
Others	Proper installation skill is required	Susceptible to electrical noise	There is lifetime of rotation parts

BASIC KNOWLEDGE for ENERGY AUDIT

Principles of Measurement

Pressure measurement

Ultrasonic Flow meter:

- Measure the flow (Q) using ultrasonic flow meter. Flow is important parameter to measure the water power, discharge velocity and other required parameters.

Pressure Gauge

- Record pressure using pressure gauge. Pressure is important parameter to determine the Total Head.

Water level meter

- This equipment is used to determine the static and dynamic water level. An important parameter to calculate the Total Head.

Tachometer

- Tachometer determines the rotation of the motor, shaft and pump

Digital Thermometer

- This device used to get temperature of critical parts of motor and pump.

Vibration meter

- Vibration meter determines the vibration of pump and motor at critical parts. This is important parameters to ensure a good installation.

Sr. #	Parameter	Unit	1st	2nd	3rd	4th
1	Date	yyyy/mm/dd				
2	Time	hh:mm				
3	Location/ Tag	-				
4	Pump (Maker/ Rating/ Type)	-				
5	Motor (Maker/ Rating)	-				
6	Discharge Pressure (p_d)	bar				
7	Discharge Pipe Dia (d)	mm				
8	Flow (Q)	m^3/h				
9	Dynamic Water Level (hpl)	m				
10	Static Water Level (hpl)	m				
11	Voltage (V) RY-YB-BR	Volt				
12	Ampere (A) R-Y-B	Ampere				
13	Power Factor (Cos ø)	-				
14	Motor Input Power (P_{mi})	kW				
15	Speed (N)	RPM				
16	**Motor** Vibration (Upper Bearing)	mm/s				
17	**Motor** Vibration (Lower Bearing)	mm/s				
18	**Pump** Vibration (Thrast Bearing)	mm/s				
19	Temperature (at Upper Bearing)	^0C				
20	Temperature (at motor coil; center)	^0C				
21	Temperature (Lower Bearing)	^0C				
22	Temperature (**Pump** Thrust Bearing)	^0C				
23	Excessive water leakage from gland	-	yes / no	yes / no	yes / no	yes / no

FINDINGS & RECOMMENDATIONS

Surveyer: Attendance:

Pump Data — Motor Data

Date(yyyy-mm-dd): - -

Time(in 24 hour scale) :

Location:

Pump Data	Motor Data
Maker:	Maker:
Rating:	Rating:
Frequency: 50 Hz	Frequency: 50 Hz

Diameter of Discharge Pipe (m)

Sr.#	Parameter	Unit	Method	Figure	Criteria for TW WASA Lahore
1	Discharge Pressure (p_d)	bar	Pressure Gauge		> 2 (WASA standard)
2	Flow (Q)	m^3/h	Ultrasonic Flow meter		To Be -20% to +10% of Design Flow
3	Dynamic Water Level (hpl)	m	Level Meter		according to design
4	Static Water Level (hpl)	m	Level Meter		according to design
5	Water Level Difference(hpd)	m	Calculated		< 8 (to be confirmed)
6	Voltage (V)	Volt	Power Analyser		380 < V < 420
7	Ampere (A)	Ampere	Power Analyser		to be less than rated current
8	Power Factor (Cos ø)	Nil	Power Analyser		> 0.90
9	Motor Input Power (P_{mi})	kW	Power Analyser		according to design
10	Speed (N)	RPM	Tachometer		> 2900 (2 pole) > 1450~ (4 pole)
11	Discharge Head (h_d)	m	Calculated		> 20 (WASA standard)
12	Frict. Losses	m	Manufacture's Estimation		4cfs: 3.07, 3cfs: 1.72, 2cfs: 2.25
13	Discharge Velocity (v_d)	m/s	Calculated		-
14	Velocity Head (hv_d)	m	Calculated		-
15	Total Head ht	m	Calculated		according to design
16	Water Power (P_w)	kW	Calculated		according to design
17	Motor Efficiency ($ή_m$)	%	Manufacture's Estimation		92% (new) 87% (rewinded)
18	Motor Output Power (P_{mo})	kW	Calculated		according to design
19	Power loss by Shaft Friction (ps)	kW	Calculated		1% of P_{mo}
20	Pump Power Input (Ppi)	kW	Calculated		according to design
21	Pump Efficiency ($ή_p$)	%	Calculated		> 78% -82% (new)
22	Total Efficiency (ήt)	%	Calculated		> 68% -75%
23	per m3 Power Consumption (Eq)	kWh/m3	Calculated		according to design
24	Motor Vibration (Upper Bearing)	mm/s	Vibration meter		< 5.1
25	Motor Vibration (Lower Bearing)	mm/s	Vibration meter		< 5.1
26	Pump Vibration (Thrast Bearing)	mm/s	Vibration meter		< 5.1
27	Temperature (at Upper Bearing)	^0C	Temperature meter		< (Ambient temp. +40) °C
28	Temperature (at motor coil; centre)	^0C	Temperature meter		< (Ambient temp. +40) °C
29	Temperature (Lower Bearing)	^0C	Temperature meter		< (Ambient temp. +40) °C
30	Temperature (Pump Thrust Bearing)	^0C	Temperature meter		< (Ambient temp. +40) °C
31	Excessive water leakage from gland	-	Observe		"no"
32	Fluctuation of( )	%	Calculated		Less than 5% (to be studied)

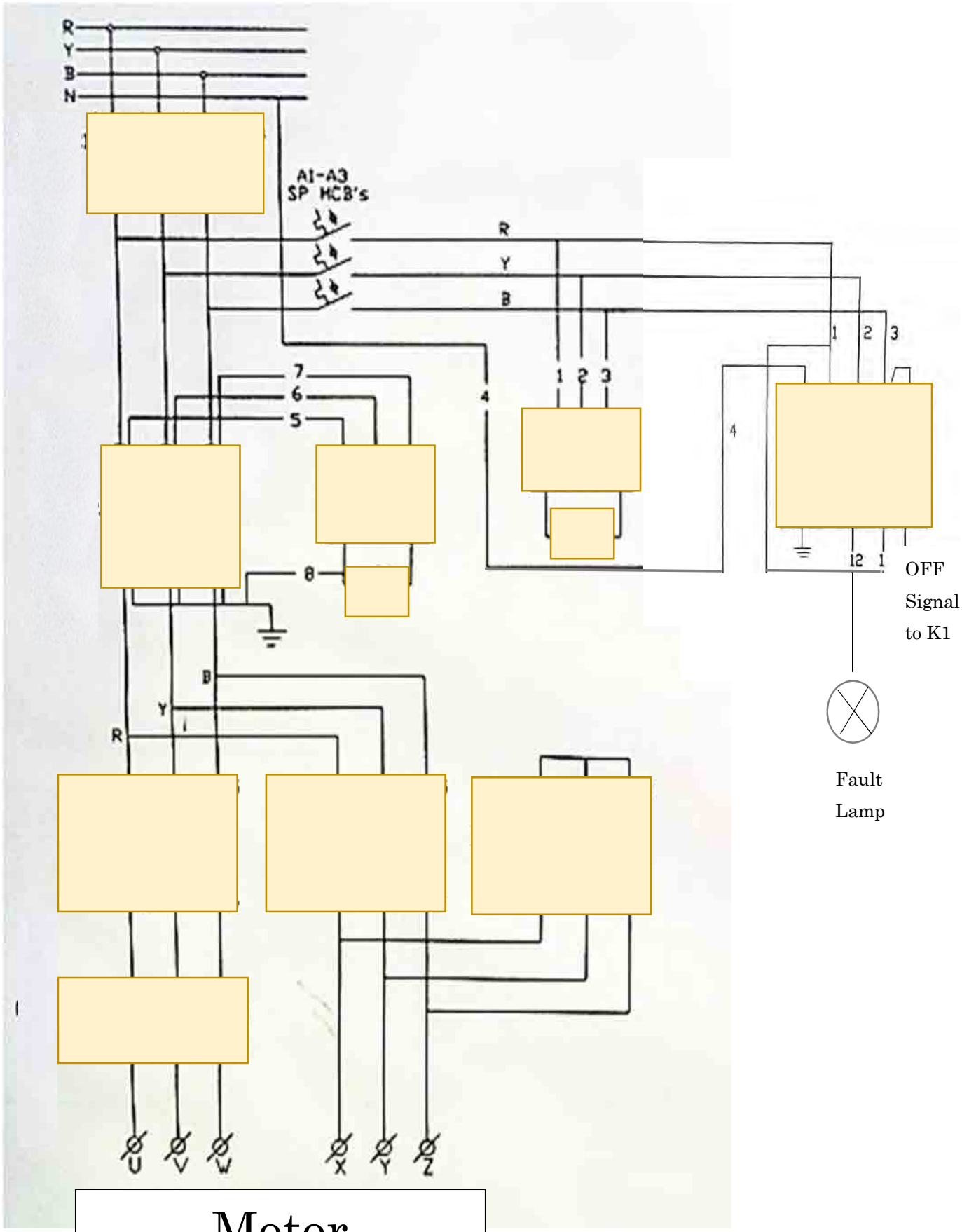
FINDINGS & RECOMMENDATIONS

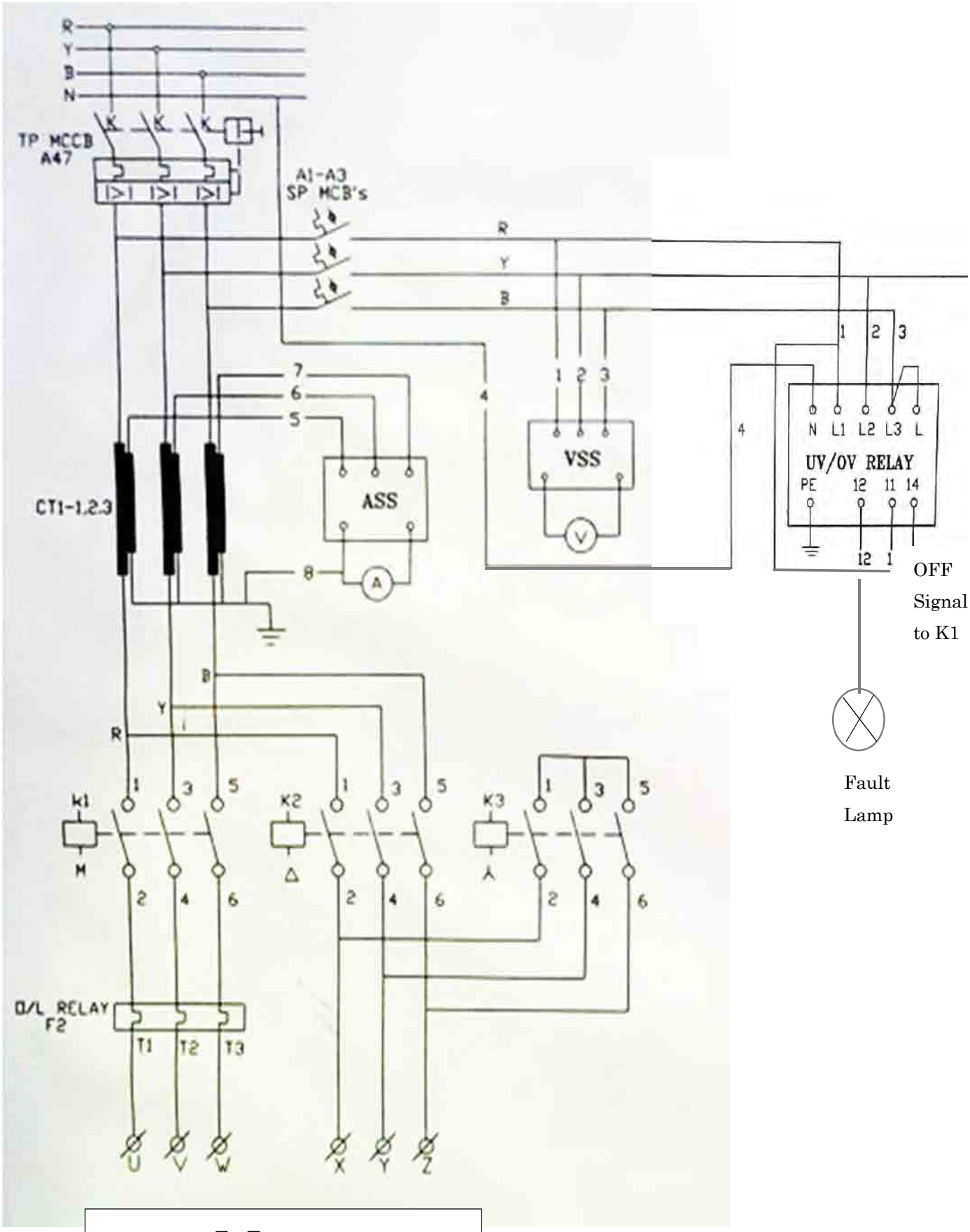
Surveyor: Attendance:

Formulas

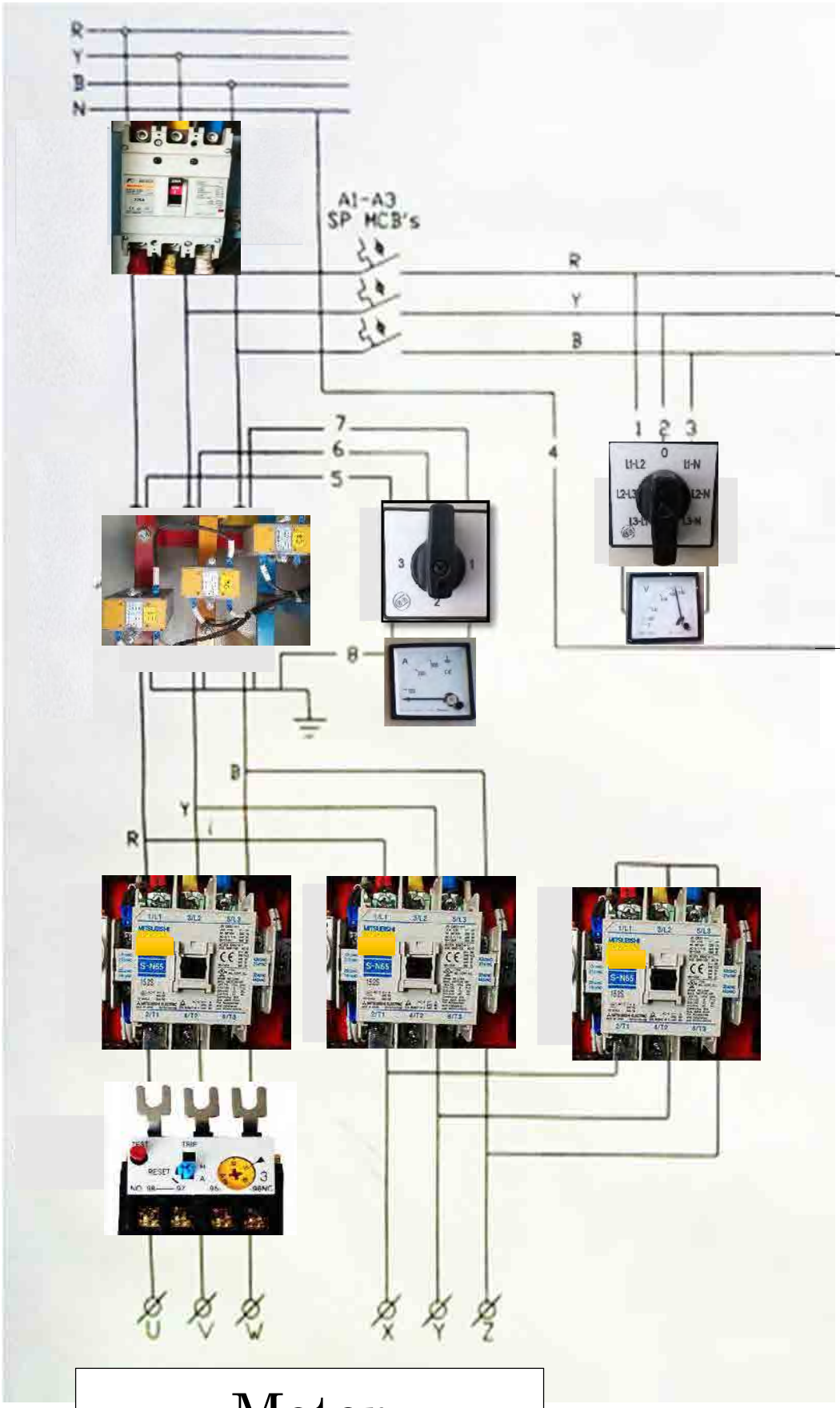
- Discharge Head (hd)
- $\mathrm{hd} = \mathrm{Pd} \times 10.13\ [\mathrm{m}]$
- Pd: Discharge Pressure [bar]
- here, Atmospheric pressure is considered as 1.013 [bar]
- Discharge Velocity (Vd)
- $\mathrm{vd} = \frac{Q}{3600 \times \frac{\pi d^2}{4}}\ [m/s]$
- Q: Flow volume [m3/h] d: inertial diameter of delivery pipe
- Velocity Head (hvd)
- $h_{vd} = \frac{v_d^2}{2g}$
- Total Head (ht)
- $h_t = h_{pl} + h_{vd} + h_d$
- hpl: Dynamic water level, hvd: velocity head, hd: discharge head
- Water Power (Pw)
- $P_w = \frac{gQh_t}{3600}$
- Here, volume Q is expressed in [m3/**hour**] unit.

- When volume Q is expressed in [m3/**min**] unit, the equation change as below;
- $P_w = \frac{gQh_t}{60}$
- Motor Output Power (Pmo)
- $P_{mo} = \eta_m \times P_{mi}$
- Here, ηm is motor efficiency. Refer to manufacturer's specification and considered a rewinded motor decreases its efficiency about 3 to5%.
- Pinput will be derived from Power Analyzer but you can also calculate it from Input Voltage, Current and Power Factor. The formula is shown below;
- $P_{mi} = \sqrt{3}\ V\ I\ cos\emptyset$
- Power Loss by Shaft Friction (ps)
- Assuming power loss by shaft friction will be 1 % of motor output.
- $p_s = 0.01 \times P_{mo}$


R
Y
B
N
A1-A3
SP MCB's
R
Y
B
1 2 3
7
6
5
4
1 2 3
4
8
12 1
OFF
Signal
to K1
B
Y
R
Fault
Lamp
U
V
W
X
Y
Z
Motor


R
Y
B
N
TP MCCB
A47
A1-A3
SP MCB's
CT1-1,2,3
ASS
VSS
UV/OV RELAY
PE
N L1 L2 L3 L
12 11 14
12 1
OFF
Signal
to K1
Fault
Lamp
K1
K2
K3
M
Δ
Y
O/L RELAY
F2
T1 T2 T3
U V W X Y Z

Motor


R
Y
B
N
A1-A3
SP MCB's
R
Y
B
7
6
5
4
B
Y
R
ZAHRA RST 25
Low-Medium-High
voltage control relay
OFF
Signal
to K1
Fault
Lamp
U
V
W
X
Y
Z

Motor

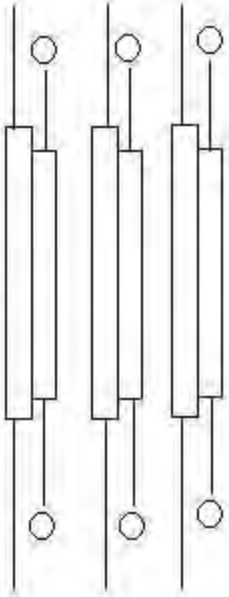
Name:_____

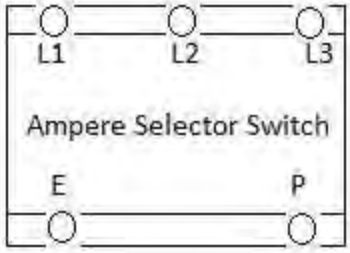
Designation:_____

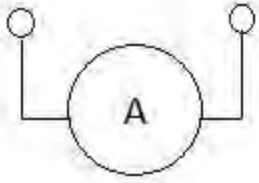
WASA:_____

EC-M1-04

Current
Transformer







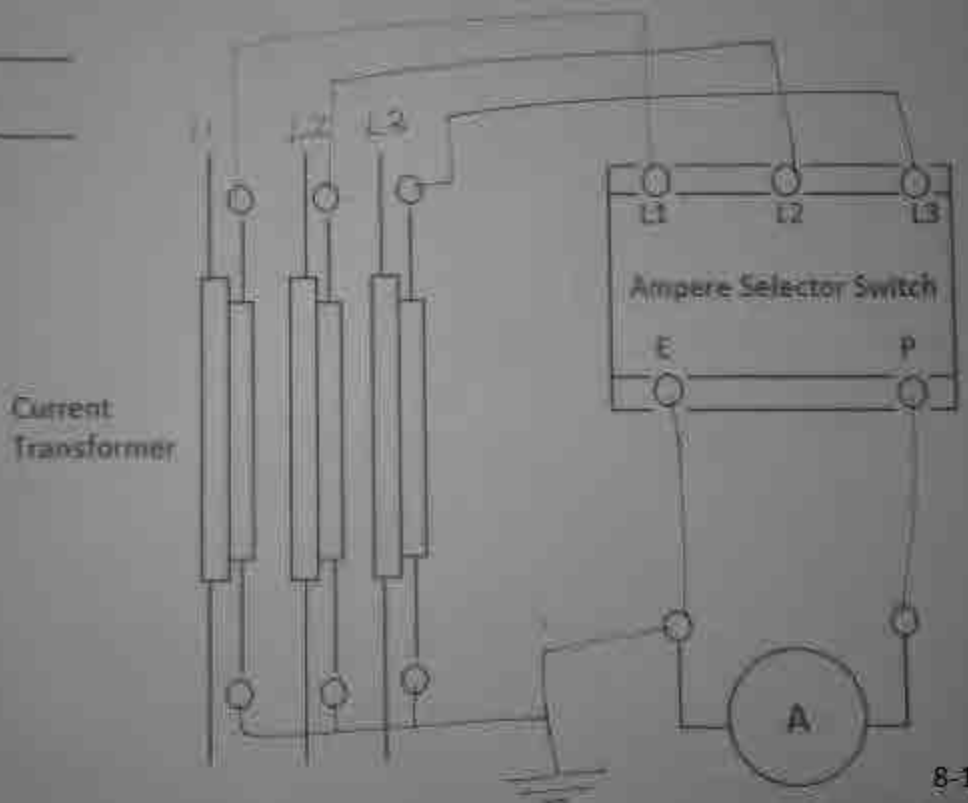
8-12-17

Name: _____

Designation: _____

WASA: _____

EC-M1-05



Current Transformer

8-12-17

EC-M1-06

Name: _____

Designation: _____

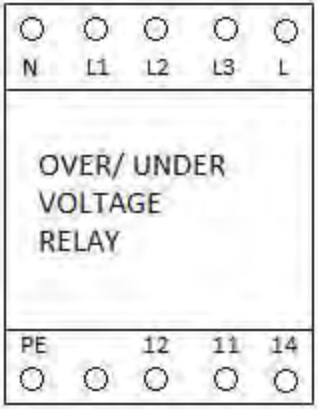
WASA: _____

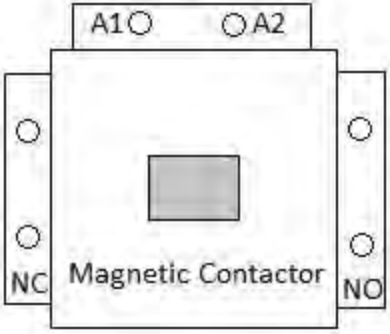
L1 _____

L2 _____

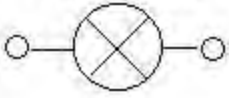
L3 _____

N _____





FAULT LAMP



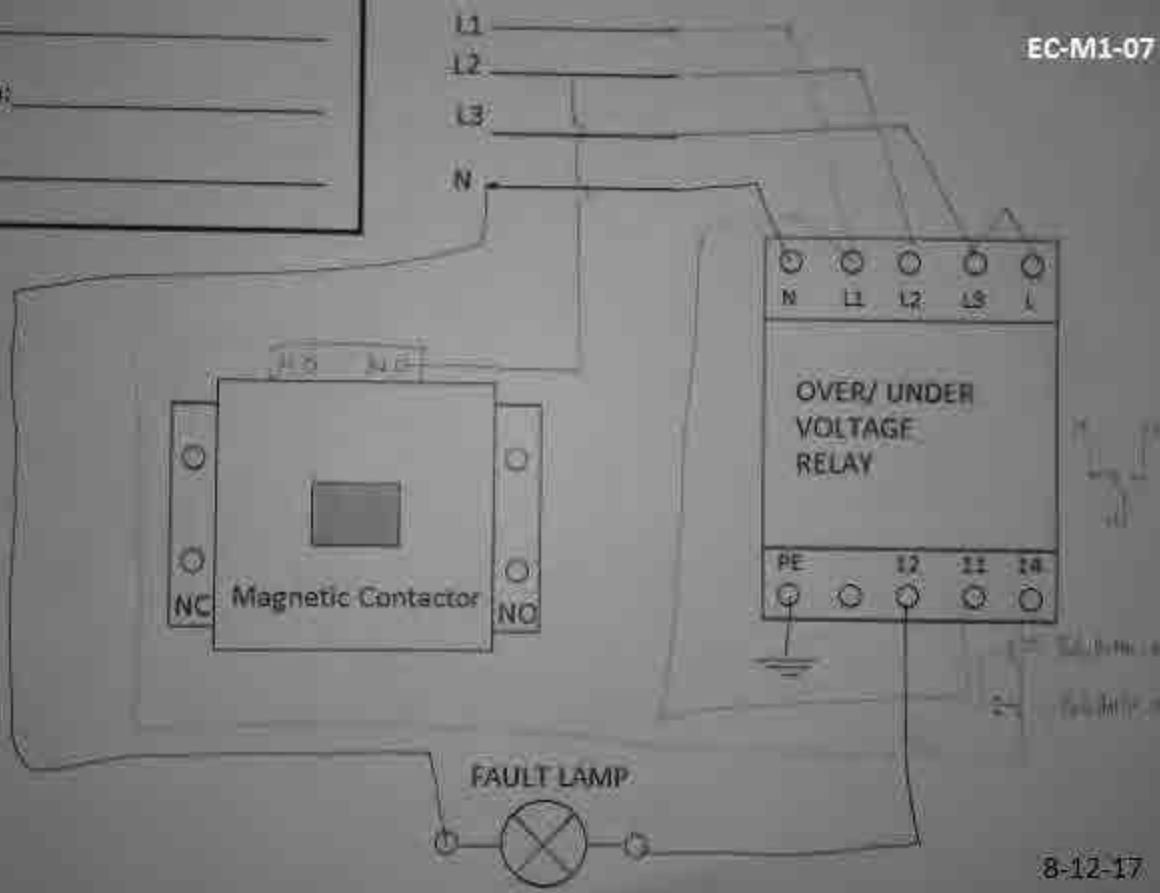
8-12-17

Name: _____

Designation: _____

WASA: _____

EC-M1-07



8-12-17

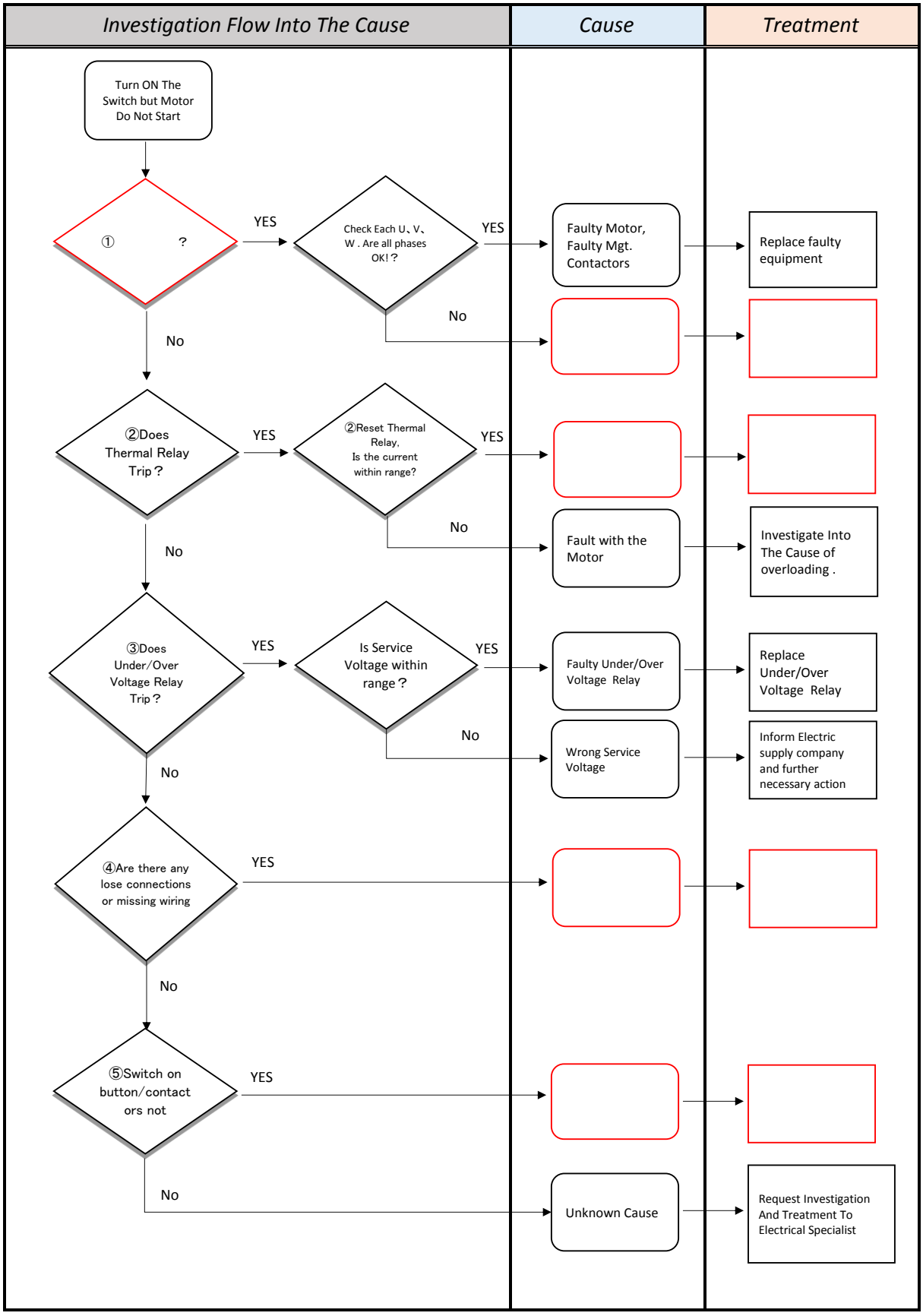
Participants Name: _____

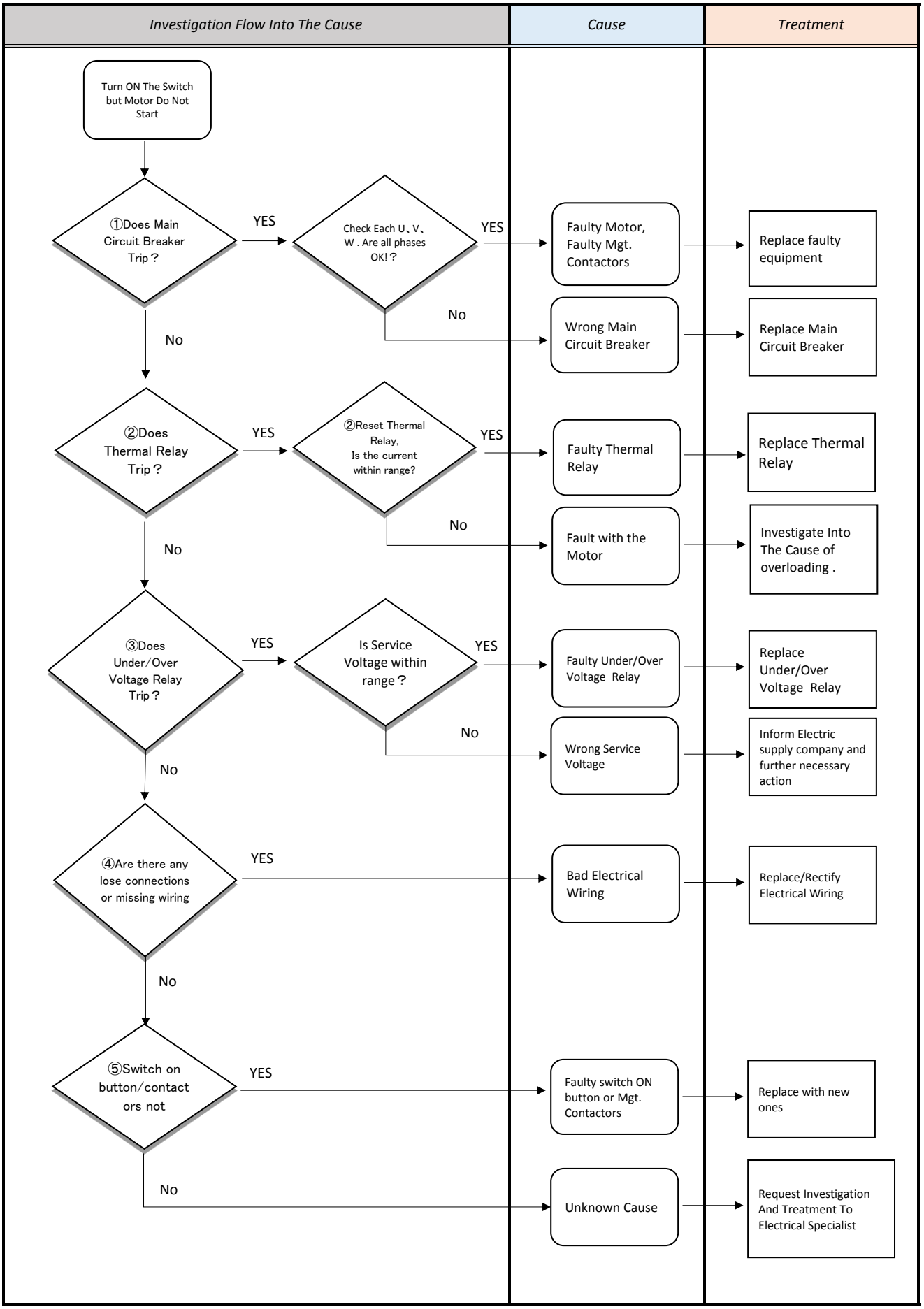
Motor Name Plate					
Voltage	**Connection**	**Ampere**	**HP**	**PF**	**RPM**
380	Delta	115	80	0.85	1480

An 80HP induction motor with Phase-to-Phase service voltages, V_1=460V, V_2=440V and V_3=470V is having issue of overheating windings. Kindly refer to the owners O&M manual and identify the fault and suggest remedy.

Over/Under voltage relay is set to V_{min}=390V and V_{max}=470V and timer is set at 7 seconds

Participant Name:_____




Investigation Flow Into The Cause
Cause
Treatment
Turn ON The Switch but Motor Do Not Start
①Does Main Circuit Breaker Trip？
YES
Check Each U、V、W . Are all phases OK!？
YES
Faulty Motor, Faulty Mgt. Contactors
Replace faulty equipment
No
Wrong Main Circuit Breaker
Replace Main Circuit Breaker
No
②Does Thermal Relay Trip？
YES
②Reset Thermal Relay, Is the current within range?
YES
Faulty Thermal Relay
Replace Thermal Relay
No
Fault with the Motor
Investigate Into The Cause of overloading .
No
③Does Under/Over Voltage Relay Trip？
YES
Is Service Voltage within range？
YES
Faulty Under/Over Voltage Relay
Replace Under/Over Voltage Relay
No
Wrong Service Voltage
Inform Electric supply company and further necessary action
No
④Are there any lose connections or missing wiring
YES
Bad Electrical Wiring
Replace/Rectify Electrical Wiring
No
⑤Switch on button/contactors not
YES
Faulty switch ON button or Mgt. Contactors
Replace with new ones
No
Unknown Cause
Request Investigation And Treatment To Electrical Specialist

Operation Time Record (Pump)

EC-M1-10

Month/Year : ／

Date : ～

Approved by (Engineer)	
Prepared by (Operator)	

Sr. No.	Date	Shift #	Operating Time		Operating Hours	Chlorine Dosing	Flow Reading (Start)	Flow Reading (Stop)	Flow Amount	Pressure	Power Factor	Voltage			Ampere		
			Turn On	Turn Off	hrs.	Y/N	m3	m3	m3	MPa	%	RY (V)	YB (V)	BR (V)	R (A)	Y (A)	B (A)
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
Total/ Sum																	

Remarks:

12/08/2017

Check List of Standard Operation Procedure for Electrical Facility

EC-M1-11

Approved by :

Inspected by :

Motor Specification: **Rated Capacity (kW/HP)** _____

Rated Voltage (V) _____**Rated Current(A)** _____

Efficiency_____**Power Factor**_____**RPM**_____

Evaluation Criteria

✓: Good ×: No care at all or need to be newly installed

△: Need to be improved —: Not available to be checked

Sr. No.	Site/Pump Name	Inspection Date	Inspection Items for Electrical Panel Condition															
			Document			Visual (Outside)						Visual (Inside)				Operation	
			Operation Record	Drawings	Vender Manual	Identification of Lamp/Switch	Status/ Fault Indication Lamps	Ampere Meter	Voltage Meter	Status Selector Switch		Cleanliness	Intrusion Path	Bypass-Circuit	Neatness of cabling	How to operate changeover switch	Frequency of Start/Stop
			Compare with the sample	Pump installation, electrical line diagram	Pump/ Panel devices	all lamps /switches have name tag	all lamps are visibly bright enough	Proper functioning and zero adjustment	Proper functioning and zero adjustment	Ampere	Voltage	No dust, sand, spider's nest, insect, small animals	No hole/ crack to let foreign matters come in	No bypass / burnt mark		Turn off by breaker or switch first.	Maximum 2-3 times/ hour
1																	
2																	
3																	

- Remarks -

12/08/2017

Device Inspection Sheet

EC-M1-12

Approved by :

Inspected by :

Motor Specification: **Rated Capacity (kW/HP) _____**

Rated Voltage (V) _____Rated Current(A) _____Efficiency_____

Power Factor_____RPM_____

Evaluation Criteria

✓: Good ×: No care at all or need to be newly installed

△: Need to be improved —: Not available to be checked

Sr. No.	Site /Pump Name	Inspection Date	Continuity Test of components (Using Clamp Meter)									Current Transformer			Relays Adjustments					
			Circuit Breakers					Magnetic Contactor			Fuse				Over/Under Voltage Relay			Over Current (Thermal) Relay		Y-Δ Timer
			MCCB	MCB 1	MCB 2	MCB 3	MCB 4	K1	K2	K3		CT1	CT2	CT3	Under Voltage Tripping Function	Over Voltage Tripping Function	±10% of rated voltage of motor	Tripping Function	Value Set	Not less than 5 seconds
1																				
2																				
3																				
4																				
5																				

- Remarks -

Preventive Maintenance Sheet for Electrical Facility

EC-M1-13

Sub Division:	**Motor Specification**			**Power (kW/HP)**	
Site Name:	**Rated Voltage (V)**	**Rated Ampere (A)**	**Efficiency (%)**	**Power Factor**	**RPM**
Equipment Name:					
	Date				
	Inspected By				
	Weather				

Activity			**Reference Value**	**Data of Site**		**Data of Site**	
Bolt Tightening			No loose point				
Insulation Resistance (MΩ)	U1-E	U2-E	≥ 1 M Ω = Good				
	V1-E	V2-E					
	W1-E	W2-E					
	U1-V1	U2-V2					
	V1-W1	V2-W2					
	W1-U1	W2-U2					
Earth Resistance Test	Earthing Pit/ Bar		< 5Ω				
	Electric Motor	Electric Panel					
Voltage by Clamp Meter (V)	RY		Rated ± 10%				
	YB						
	BR						
Ampere by Clamp Meter (A)	R		Rated ± 5%				
	Y						
	B						
Power Factor			≥ 0.9				
Vibration	Upper Bearing	Lower Bearing	< 5.1 mm/s				
Revolution Per Minute (RPM)			1450 (4 Pole)				
Temperature	Upper Bearing	Lower Bearing	< 90˚C				
	Shaft						

- Remarks -

Reference for Insulation Resistance Value:

Good → more than 1.0MΩ

Need to Adjust, Clean,Care → 1.0MΩ ~ 0.4MΩ

Need to repair immediately →less than 0.4MΩ

ENERGY AUDIT INPUT FORM (For Site)

Sr. #	Parameter	Unit	Criteria	1st
1	Date	dd/mm/yy		27/03/2018
2	Time	hh:mm		
3	Location/ Tag	-		
4	Pump (Maker/ Rating/ Type)	-		KSB/ ( ) / Mixed.
5	Motor (Maker/ Rating)	kw		ABB ( )
6	Discharge Pressure (p_d)	bar	> 2 (WASA standard)	
7	Flow (Q)	m^3/h	To Be -20% to +10% of Design Flow	
8	Dynamic Water Level (hpl)	m	according to design	
9	Static Water Level (hpl)	m	according to design	
10	Voltage (V)	Volt	±10% of rating	
11	Ampere (A)	Ampere	to be less than rated current	
12	Power Factor (Cos ø)	Nil	> 0.90	
13	Motor Input Power (P_{mi})	kW	according to design	
14	Speed (N)	RPM	> 1450~ (4 pole)	
15	Motor Vibration (Upper Bearing)	mm/s	< 5.1	
16	Motor Vibration (Lower Bearing)	mm/s	< 5.1	
17	Pump Vibration (Thrast Bearing)	mm/s	< 5.1	
18	Temperature (at Upper Bearing)	^0C	< (Ambient temp. +40) °C	
19	Temperature (at motor coil; center)	^0C	< (Ambient temp. +40) °C	
20	Temperature (Lower Bearing)	^0C	< (Ambient temp. +40) °C	
21	Temperature (Pump Thrust Bearing)	^0C	< (Ambient temp. +40) °C	
22	Excessive water leakage from gland	-	No	

ENERGY AUDIT REPORT

Date: 11-12-2017

Time : 10:25 am

Location: Tanki #3, Township

Static water Level (m) : 45.1

Pump Data

Make KSB

Rated Discharge (Q) 3 cusecs

Motor Data

Make ABB

rated KW 90

Frequency 50 C/S

Sr. #	Parameter	Unit	Criteria	
1	Disch. Pressure (p_d)	bar	> 2 (WASA standard)	**1.0**
2	Flow (Q)	m^3/h	- 20% to +10% of Design Flow	**315**
3	Pumping Water Level (h_{pl})	m	according to design	**49.5**
4	Voltage (V)	Volt	±10% of rating	**399**
5	Ampere (A)	Amp	to be less than rated current	**112.0**
6	Power Factor (Cos ø)	Nil	> 0.90	**0.99**
7	Motor Input Power (P_{input})	KW	according to design	**76.6**
8	Speed (N)	RPM	> 1450~ (4 pole)	**1482**
9	Frict. Losses	m	Specified	**1.72**
10	Motor Efficiency ($ń_m$)	%	Specified	**92.0**
11	Pump Efficiency ($ń_{Pump}$)	%	Calculated	**76.0**
12	Total Efficiency	%	Calculated	**69.9**
13	per m^3 consumption	kwh/m^3	< 0.35	**0.24**
14	Motor Vibration (Upper Bearing)	mm/s	< 5.1	**3.4**
15	Motor Vibration (Lower Bearing)	mm/s	< 5.1	**1.4**
16	Pump vibration (Thrust bearing)	mm/s	< 5.1	**1.2**
17	Temperature at (Upper Bearing)	°C	< (Ambient temp. +40) °C	**33.6**
18	Temperature at (Lower Bearing)	°C	< (Ambient temp. +40) °C	**31.8**

FINDINGS & RECOMMENDATIONS

O & M of Electrical Equipment
WSD 5231

Generators

Module 2

Agenda

- ✓ Introduction to generators
- ✓ Basic assembly design of generators
- ✓ Components of generator
- ✓ SOP's and Best Industry Practices
- ✓ Periodic Maintenance and record keeping
- ✓ Reliability based preventative maintenance.
- ✓ Troubleshooting for various failures

Class Introduction

- ✓ Importance of Generators in WASA operations
- ✓ What do we cover in this module?
- ✓ What to expect in this module?
- ✓ Goal and objectives of this module?

Introduction to Generators

A generator is machinery that converts mechanical energy to electrical energy by electromagnetic action to generate electrical power

✓Principle of Generator

✓Frequency of the synchronous generator is determined according to the rate of rotation

✓Basic components of Generator:

1. **Diesel Engine**
2. **Alternator**
3. **Control Panel**

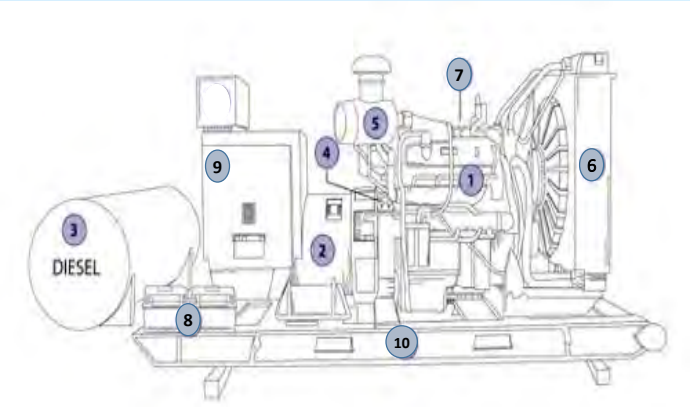
Flow of Systems

1. Starter motor starts operation using power supplied by batteries
2. Crank Shaft of engine starts rotating
3. Combustion cycle starts
4. Rotor of alternator starts to rotate
5. Stator of alternator generates power

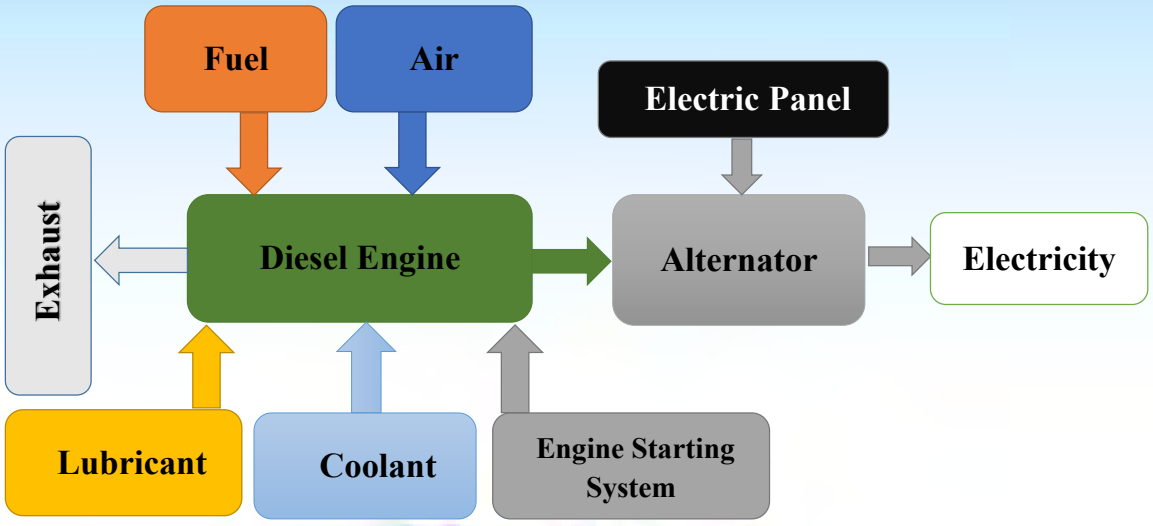
Basic design of generator

✓ Major components of a diesel generator

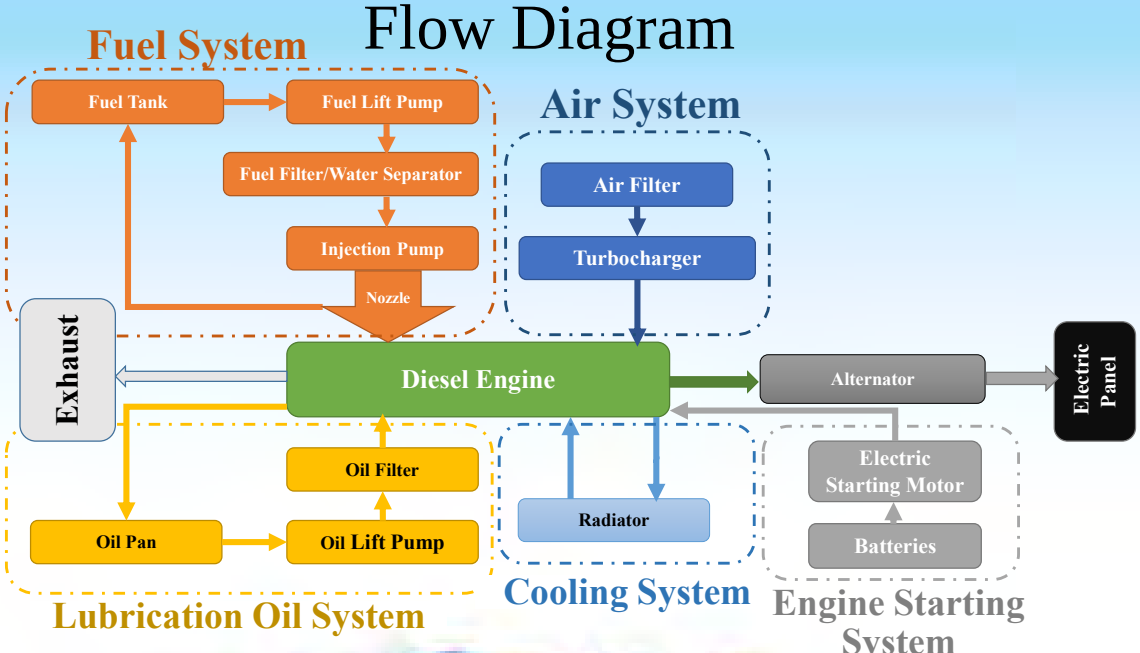
1. Engine
2. Alternator
3. Fuel Tank and related system
4. Voltage Regulator
5. Air Intake and Exhaust Systems
6. Cooling Systems
7. Lubrication System
8. Battery (Engine Starting System)
9. Control Panel
10. Main Assembly / Frame



Block Diagram of generator



Flow Diagram



1.Engine

- ✓ The engine is the source of the input mechanical energy to the generator.
- ✓ The size of the engine is directly proportional to the maximum power output the generator can supply.
- ✓ Source of energy for the operation of Generator

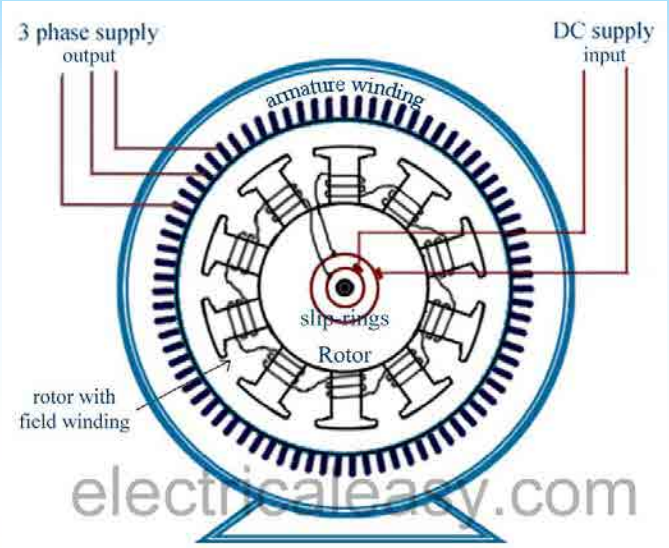
Engine

2. Alternator

- ✓ The alternator is the mechanical equipment that produces electrical output from the mechanical input supplied by the engine.
- ✓ It is coupled to the diesel engine through a drive shaft.

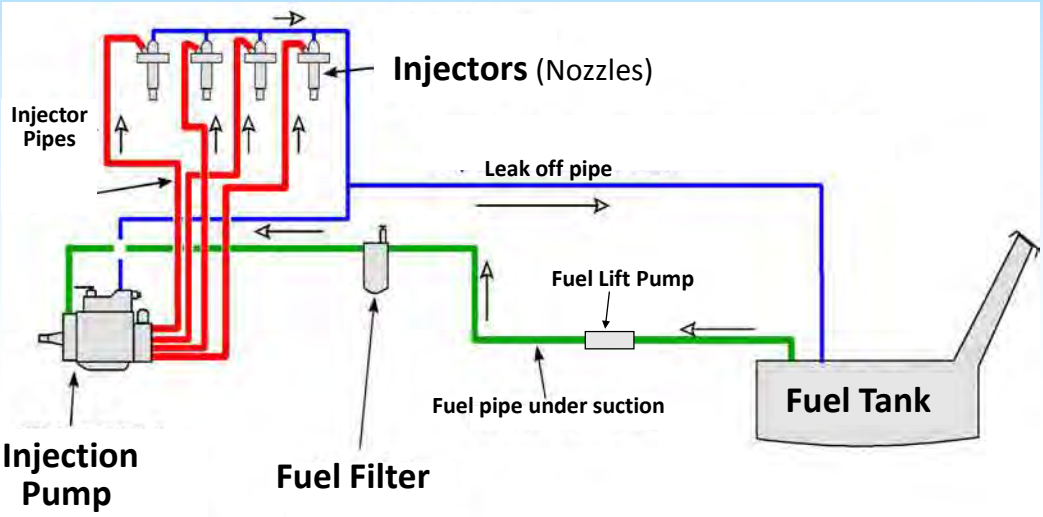
Alternator

2. Alternator



2. Alternator

3.Fuel System



Components of Fuel System

Fuel Tank	Fuel Lift Pump	Fuel Filter
		
Store enough fuel for combustion.	Lift the fuel from the fuel tank	Remove any solid particle in fuel

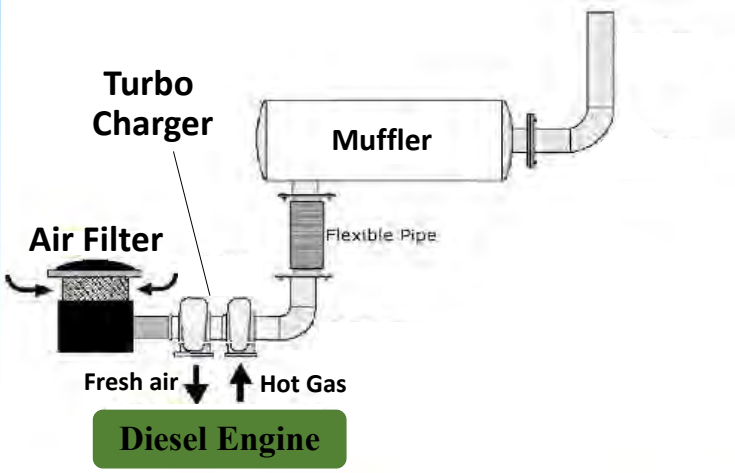
Components of Fuel System

Fuel Water Separator	Injection Pump	Nozzle
		
Separate and remove water from the fuel	**Inject fuel through nozzles at certain pressure**	**Throw fuel into the cylinders in small particle form**

4. Automatic Voltage Regulator (AVR)

AVR function is to control the magnetic field of the generator such that the output voltage will be constant.

5. Air Intake & Exhaust Systems



Typical Air Intake and Exhaust System

Components of Air Intake & Exhaust System

Air Filter	Turbocharger
	
Clean air from dust particles	**Compress air before intake for better combustion**

6. Cooling System

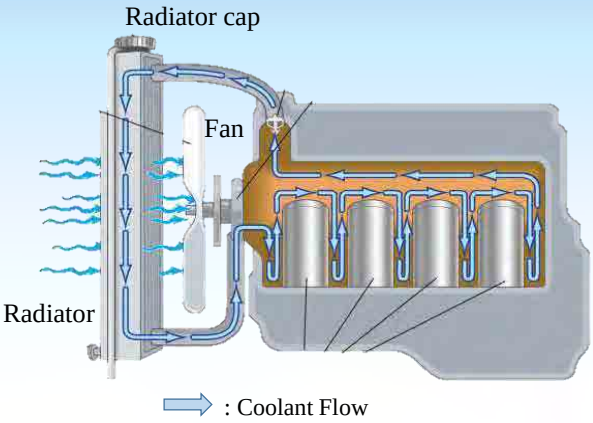
Function:

This system maintains the temperature of the engine assembly by introducing coolant into cooling channels. After completing the cycle coolant temperature increases which is then passed through radiator to radiate heat.

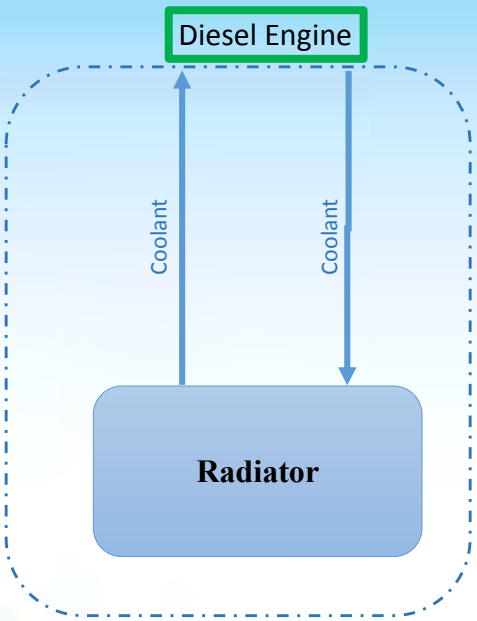
Components:

1. Radiator/ Charge air cooler
2. Thermostat

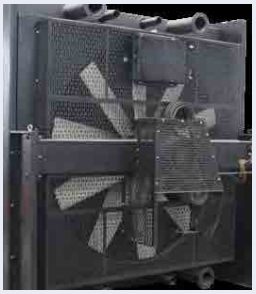
6. Cooling System



Cooling System

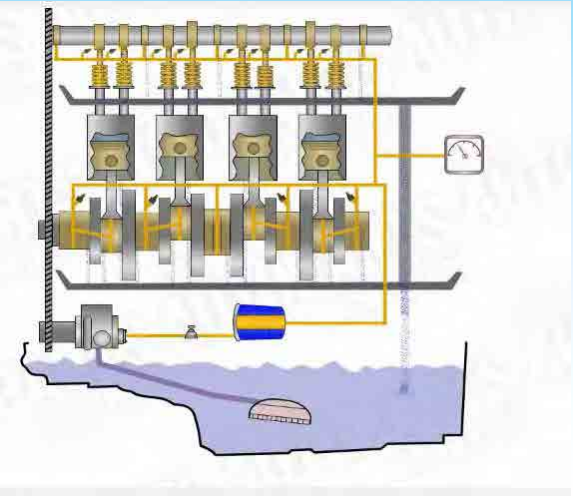


Components of Cooling System

Radiator	Fan
	
Reduce the temperature of the coolant	**Provide fresh air to radiator for cooling coolant**

7. Lubricating System

- ✓ Generator comprises moving parts in it's engine, So lubrication is required for long lasting operation.
- ✓ The generator's engine is lubricated by oil stored in an oil pan.



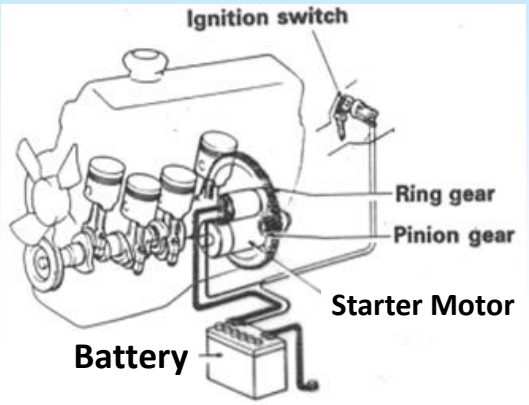
Lubrication system

Components of Lubricating System

Oil Pan	Oil Lift Pump	Oil Filter
		
Store enough engine oil for lubrication	**Lift and send oil from the oil pan to the oil filter and keep circulation**	**Remove any pollution or solid particle in engine oil**

8. Engine Starting System

- ✓ The start function of a generator is battery-operated.
- ✓ The engine needs initial rotating power to start combustion cycle so that starting motor provides the power by consuming battery DC power
- ✓ Battery is charged by DC alternator during generator operation



Components of Fuel System

Battery	Starter Motor	Alternator For Battery Charge
		
Provide starting current to the starter motor	**Start rotation of engine from the rest position**	**Generate power and charge the battery by utilizing engine rotation**

9. Control Panel

- ✓ This is the user interface of the generator and contains provisions for electrical outlets and controls.
- ✓ Electric start and shut-down
- ✓ Engine gauges
- ✓ Generator gauges
- ✓ Alarm monitoring
- ✓ Data logging
- ✓ Other controls

Electrical Control panel

Components of Electrical System

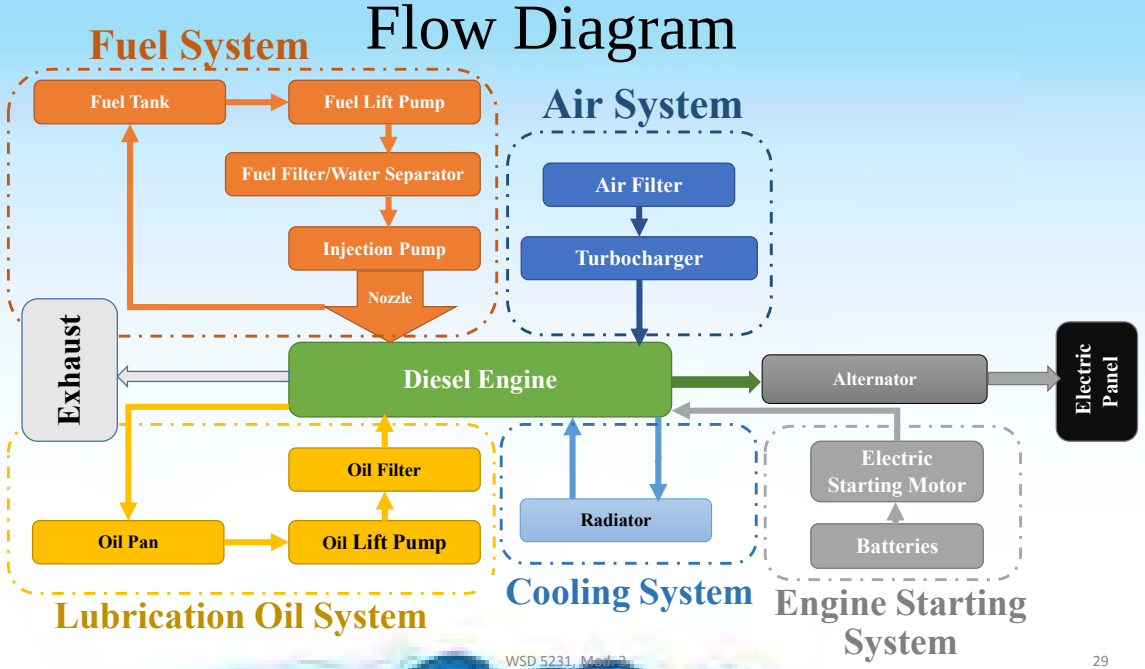
Alternator (Main)	Electrical Panel	Cables
		
Provide main alternative power supply	**Monitor and control the system through sensors and provide electrical energy with protection**	**Provide electrical connectivity between the alternator and other electrical component**

10.Main Assembly / Frame

- ✓ All generators, portable or stationary, have customized housings that provide a structural base support.
- ✓ The frame also allows for the generated to be earthed for safety.

Main frame of Diesel Generator

Flow Diagram



Capacity Calculations

- No specific or standard sizing solution is available.
- Highly depends upon the site conditions and running loads.
- Some manufacturers provide guide to estimate the required generator sizes.

Capacity Calculations

Following steps are required to calculate required size of the generator:

Step 1: Calculate the power of all non-motor loads

Step 2: Calculate starting power of the largest motor and running power of all other motors.

Step 3: Add all motor's running load and starting load of the largest motor

Step 4: Add non motor loads into the value of step 3

Step 5: Select Generator's rating of at least 125% of the final answer of step 4

Standard Operation Procedure for Generator

Electrical Connection's Overview

Standby Diesel Generators

Changeover Switch

Electrical Panel

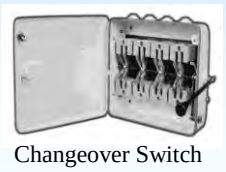
Motor of Pump

WAPDA Line
(11kV, 3phases)

Incoming Pole

Electrical Connection's Overview

Standby Diesel Generators



Changeover Switch

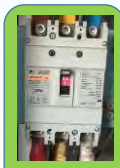
Electrical Panel

Motor of Pump

WAPDA Line
(11kV, 3phases)

Incoming Pole

Transformer
11kV → 400V

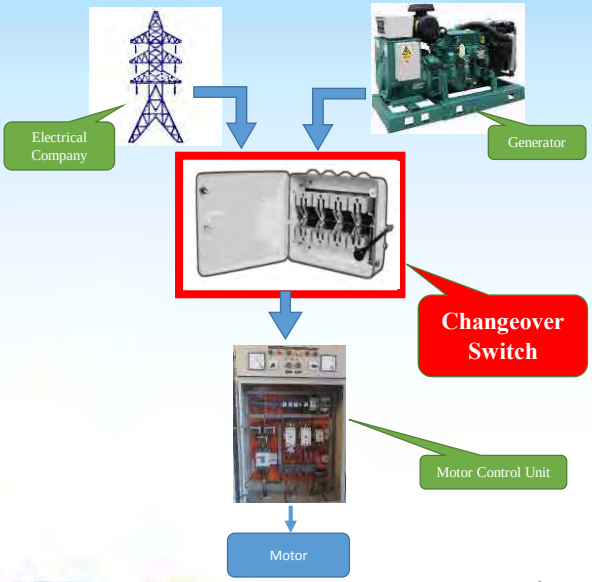


Main Circuit Breaker

Terminal Box

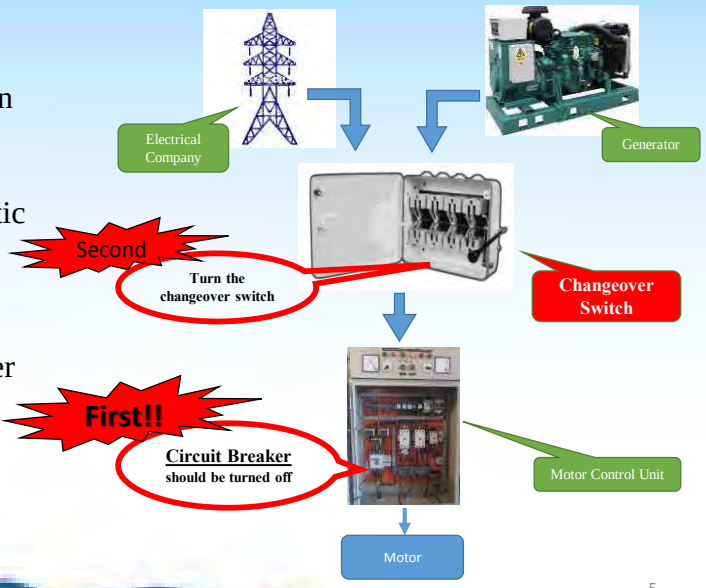
Changeover Switch Operation

- ✓ Change over Panels are used to switch between primary and auxiliary power source. It is used in case of multiple connections from the electric supply company or generators



How to operate changeover switch ??

- ✓ Don't directly open/turn the changeover switch during operation of load
- ✓ Turn off the circuit breaker/magnetic contactor first !!
- ✓ Otherwise, The terminal of changeover switch would encounter sparking



5

Best practices in Generator Operations

Standard operating procedure **before operation**

Inspect the site

- **No Leakages**
- **No Unusual smell/ odour**

Inspect the generator

- **Circuit breaker of the generator**
- **Connections of batteries are fine**
- **No loose screw/ bolt**
- **Enough amount of fuel**
- **No indication or warning lamps are turned on**

Electrical isolation

- **Turn off the following devices first:**
- **Main circuit breaker of Electrical Company's line**
- **Circuit breaker of Motor control unit**
- **Circuit breaker of the generator**
- **<u>Rotate changeover switch to generator</u>**

Best practices in Generator Operations

Standard operating procedure **during operation**

Start and Observe

- **Turn on the Main Circuit Breaker of the Generator**
- **Start the generator**
- **The sound of generator should be normal**
- **Examine the frequency and voltages**

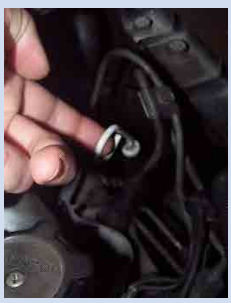
Connect the generator

- **Wait for 30-40 seconds till confirming voltage and frequency get stable enough**
- **Turn on the circuit breaker of the motor control unit**

Observe the operation

- **Sound should be normal**
- **No leakages of air, gas and oil from expected parts**

Parameters To Be Cared For Before Operation

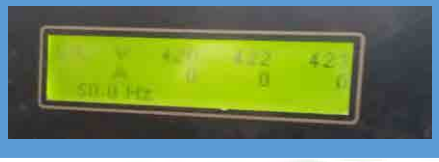
1. Circuit Breaker Off	2. Fuel Level	3. Battery water Level	4. Oil Level
			

Parameters To Be Cared For Before Operation

5. Coolant Level	6. Site Inspection		
	Leakage	Odor	General condition of Generator

Parameters To Be Cared For During Operation

1. Voltage	2. Frequency	3. Current	4. Over Heat



Parameters To Be Cared For During Operation

5. Earth Leakage	6. Gas, Air, Oil Leakage, Vibrations/ Abnormal noise
	

Preventative Maintenance & Record Keeping

Preventive Maintenance

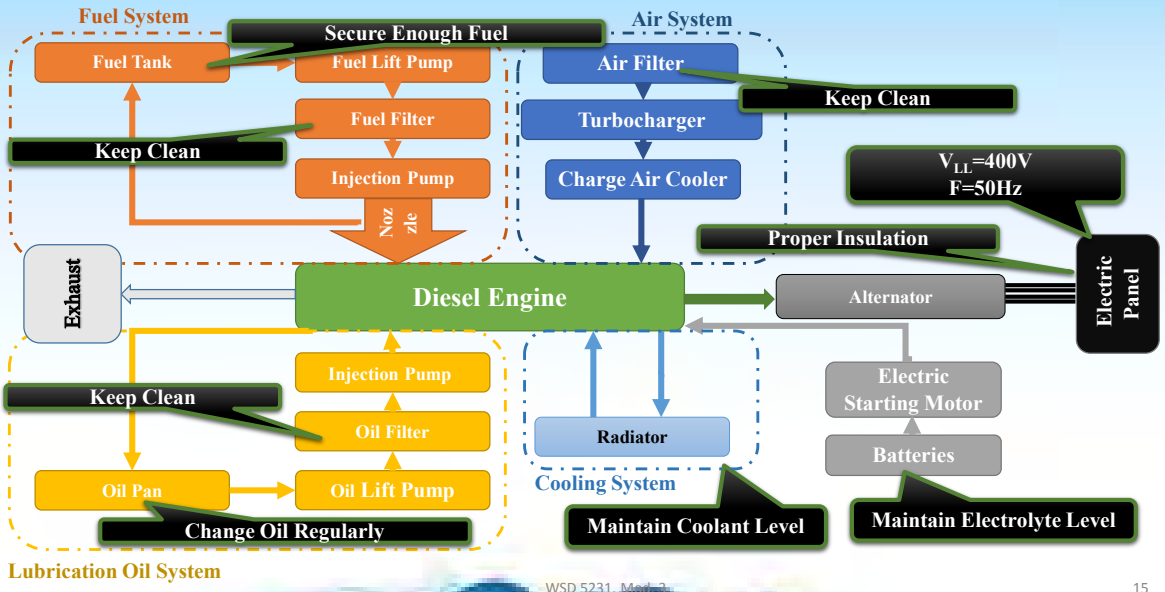
- ✓Reduce uncomfortable operation for main components and increase the lifetime of facility
- ✓Tracking data indicates latent failures in the early stage before it leads to a breakdown
- ✓Fault detection in the early stage contributes to sustainable water supply service

Necessity of Maintenance

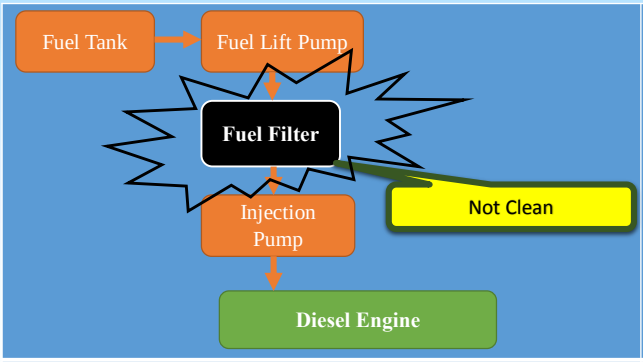
An early warning is generated by the generator before the occurrence of many failure. One should keep special intension to the device during operation, maintenance and regular inspection to avoid major problems. Some of the problem which can be observed during the operation of the device are:

a. Engine misfire
b. Vibration
c. Unusual engine noise
d. Sudden changes in engine operating temperatures
e. Excessive smoke
f. Increase in oil consumption
g. Increase in fuel consumption

How should the generator be?

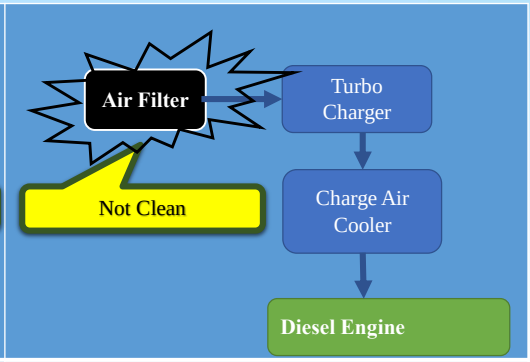


Necessity of maintenance



Problems:
- Engine Misfires
- Engine Runs Rough
- Low Output Power

Remedy:
- **Replace or clean the fuel filter**



Problems:
- Engine Misfires
- Dark Smoke
- Lower Acceleration

Remedy:
- **Replace or clean the air filter**

Daily and Periodic Maintenance Sheet

Sr. No.	Activities	Service Type				Last Activity Date	Year____ Month____				
		Daily	Weekly	Monthly	6 Months		1	2	3	4	5
1	Visual Inspection	●									
2	Check Coolant Level	●									
3	Check Oil Level	●									
4	Check Fuel Level	●									
5	Check Charge Air Piping	●									
6	Check and Clean Air Cleaner		●								
7	Check Battery Charger		●								
8	Drain Fuel Filter		●								
9	Drain Water From Fuel Tank		●								
10	Check Coolant Concentration			●							
11	Check Drive Belt Tension			●							
12	Drain Exhaust Condensate			●							
13	Check Starting Batteries			●							
14	Change Oil and Filter				●						
15	Change Coolant Filter				●						
16	Clean Crankcase Breather				●						
17	Change Air Cleaner Element				●						
18	Check Radiator Hoses				●						
19	Change Fuel Filters				●						
20	Clean Cooling System				●						

17

ITEM	Daily	50 Hrs	300 Hrs	1000 Hrs	2000 Hrs
Inspect, adjust or replace alternator or fan belt	■				
Check cooling system coolant level	■				
Check driven equipment	■				
Inspect engine air cleaner service indicator	■				
Check engine oil level	■				
Drain fuel system primary filter/water separator	■				
Walk around inspection	■				
Drain tank water and sediment		■			
Check battery electrolyte level			■		
Clean/replace engine air cleaner element			■		
Inspect/clean engine ground			■		
Change engine oil and filter			■		
Replace water separator element			■		
Replace fuel system secondary filter			■		
Inspect/replace hoses and clamps			■		
Inspect/adjust engine valve lash				■	
Inspect aftercooler core					■
Inspect alternator					■
Inspect engine mounts					■
Inspect starting motor					■
Inspect turbocharger					■
Inspect water pump					■

18

Daily Operation & Maintenance Record

Daily Operation and Maintenance Record (Generator)

Month/Year : ／

Date : ～

Approved by (Engineer)

Prepared by (Operator)

	Items	Unit	Standard/ Rated	Date ( )	( )	( )	( )	( )	( )	( )	( )	Average	Total
Operation Record	Operating Time	-		: ～					～ :	: ～ :	: ～ :		
	Operating Hours	hrs.											
	Voltage RS	V	400										
	ST	V											
	TR	V	400										
	Frequency	Hz	50										
	Energy Consumption	KWh											
Maintenance Record	Coolant Level	✔									Remarks		
	Fuel Level	L											
	Engine Oil Level												
	Alternator and Fan Belts	✔											
	Driven Equipment	✔											
	Walk Around Inspection	✔											

Operation Record
Operation Time, Operation Hour, Voltage, Frequency, Energy Consumption

Daily Maintenance Record
Coolant Level, Fuel Level, Oil Level, Fan Belt, Driven Parts, Walk-Around Inspection

Daily Maintenance Checks

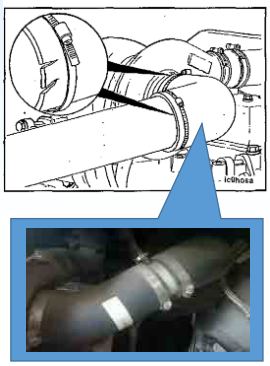
- ***Electric panel***

Electric and control panel must be inspect before operation. There must be no spark or smell etc. In case of spark or smell, check the connections of the devices and rectify the problem immediately.

- ***Air intake piping***

Visual inspect:
- Intake piping wear points
- Damages to piping
- Loose clamps or punctures that can damage the engine

Replace damaged pipe and tighten loose clamps, as necessary, to prevent the air system from leaking.



Daily Maintenance Checks

Walk-around inspection

To look for any…

- Leaks
- Damaged Parts
- Worn of Damaged belts
- Any change in engine appearance
- Odor of fuel

Daily Maintenance Checks

- Maintenance check

Visually inspect piping points for wear points and damage, loose clamps or punctures.

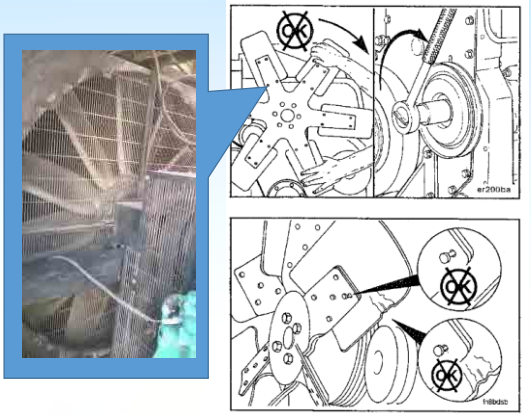
Replace damage piping and replace loose clamps.

Daily Maintenance Checks

Cooling fan

- ✓ A visual inspection is required daily.
  Check for cracks, loose rivets, bent or loose blades.
  Check the fan if it is securely mounted.

- ✓ Do not rotate the engine by pulling or prying on the fan. Use the accessory driveshaft or the crankshaft barring tool to rotate the crank shaft.



Cooling System

- ✓ The charge-air cooler piping and hoses should be inspected regularly for leaks, holes, cracks, or loose connections. Tighten the hose clamps as necessary. In addition, inspect the charge-air cooler for dirt and debris that may be blocking the fins. Check for cracks, holes, or other damage.

Cooling System

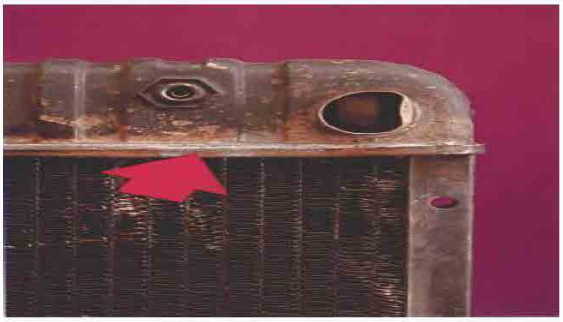
- Inspect for Reuse

Visually inspection is required to check for cracks, loose rivets and bent or loose blades.

Do not rotate the engine by pulling or prying on the fan. Fan blades can be damaged causing the fan to fail and cause personal injury.

Daily Maintenance Checks

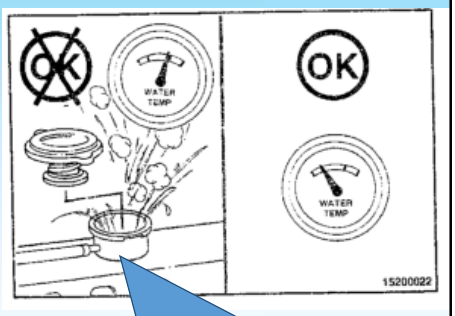
- ✓ External coolant leaks
- ✓ Belt condition-cracked or loose
- ✓ Block heater – on constantly or leaking
- ✓ Hoses – leaking, soft, brittle, bulging
- ✓ Radiator – Leaking, plugged, broken fan shroud

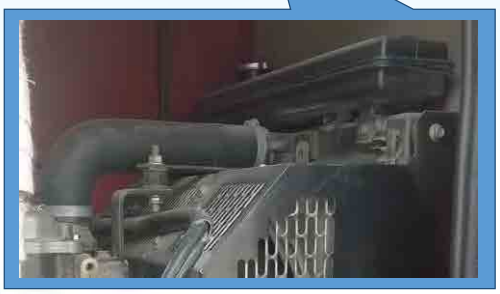


Daily Maintenance Checks

Engine coolant level

- ✓ Do not remove the pressure cap from the hot generator. Wait until the coolant temperature is below 50 ℃ before removing the pressure cap.
- ✓ To add coolant, the ratio of coolant and anti-freeze must be according to the recommended weather conditions.



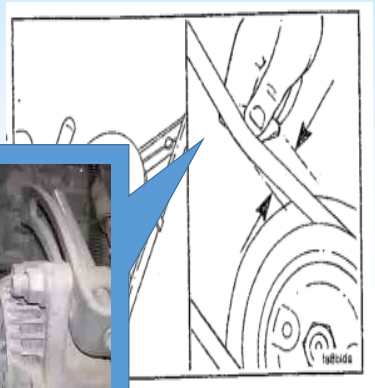


Daily Maintenance Checks

Drive belts

Inspect the belt daily. Check the belt for intersecting cracks. Replace the belt if it is frayed or has pieces of material missing.
Belt damage can be caused by:

- •Incorrect tension, size or length
- •Pulley misalignment
- •Severe operating environment
- •Oil or grease on the side of the belt
- •Aging degradation



Checking the belt tension

- Use a ruler to find the midway point on the belt's longest run between pulleys. Hold the belt between finger and thumb at this point and move it from side to side.
- See how much it deflects at the center of the run.
- If it moves more than 1/2 in. (13 mm) it is too slack - any less movement and it is too tight. Check the exact deflection recommended in the car handbook.

Fuel System Check

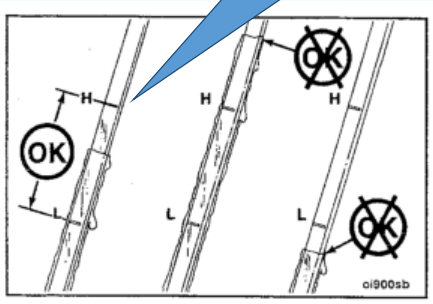
- ✓ With the generator set operating, inspect the fuel supply lines, return lines, filters, and fittings for cracks or abrasions.
- ✓ Make sure the lines are not rubbing against anything that could cause an eventual failure.
- ✓ Repair any leaks or alter line routing to eliminate wear immediately.

Fuel System

Daily Maintenance Checks

Engine lubrication oil level

- ✓ The engine must be level to check the lubrication oil level.
- ✓ Shut off the engine for an accurate reading. Wait at least 15 minutes after shutting off the engine to check the oil level. This allows oil the time to drain into the oil pan.



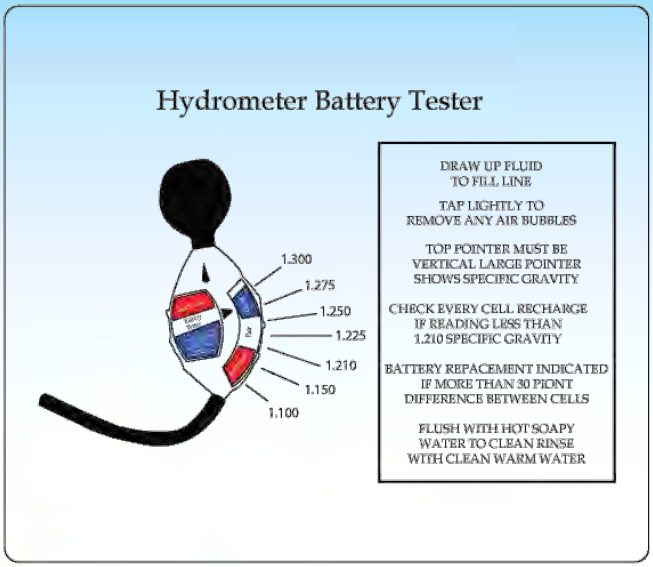
DC Electrical- Areas of concern

DC electrical system: Check the terminals on the starting batteries to make sure the connections are clean and tight. Loose or corroded connections create resistance, which can hinder starting.

1. Battery Charger - voltage and amperage
2. Condition of batteries-Change every 24-36mths
3. Wiring - connections
4. D/C Alternator – Belts, connections

Battery maintenance check

- ✓ Avoid starting failures by making sure the starting batteries are fully charged and tested regularly under a load.

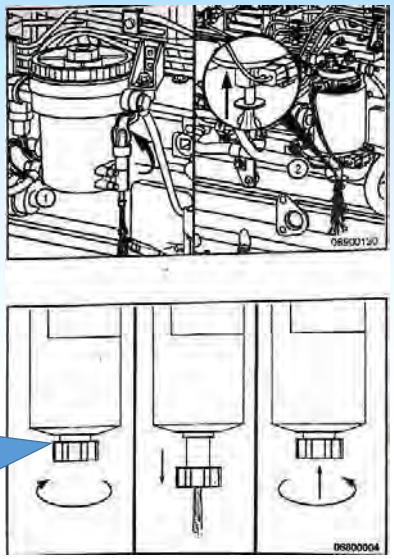


Daily Maintenance Checks

Fuel water separator/ filter

Drain the water and sediments from the separator daily. But before draining, shut off the engine. Use hand to open the drain valve. Drain the filter sump until the clear fuel is visible.

After that close the valve
and turn it until it is hand-tight.
Do not over tighten the valve.
It can cause the damage of the threads.

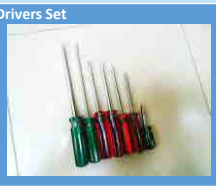
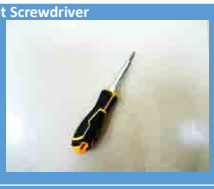
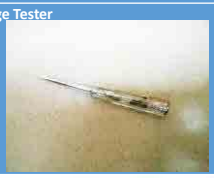


Engine Operation Report

Report any of the following issues:

- Low lubrication oil pressure
- Low Power
- Power increases or Engine surge
- Erratic or no accelerator response or control
- Warning lights
- Unusual Engine noise
- Excessive Smoke

Necessary Tools

1. Insulated Rubber Glove 	2. Screw Drivers Set 	3.Helmet 
4.Ratchet Screwdriver 	5. Ratchet Socket Wrench Set 	6. Adjustable Wench 
7. Voltage Tester 	8. Clamp Type Multi-meter 	

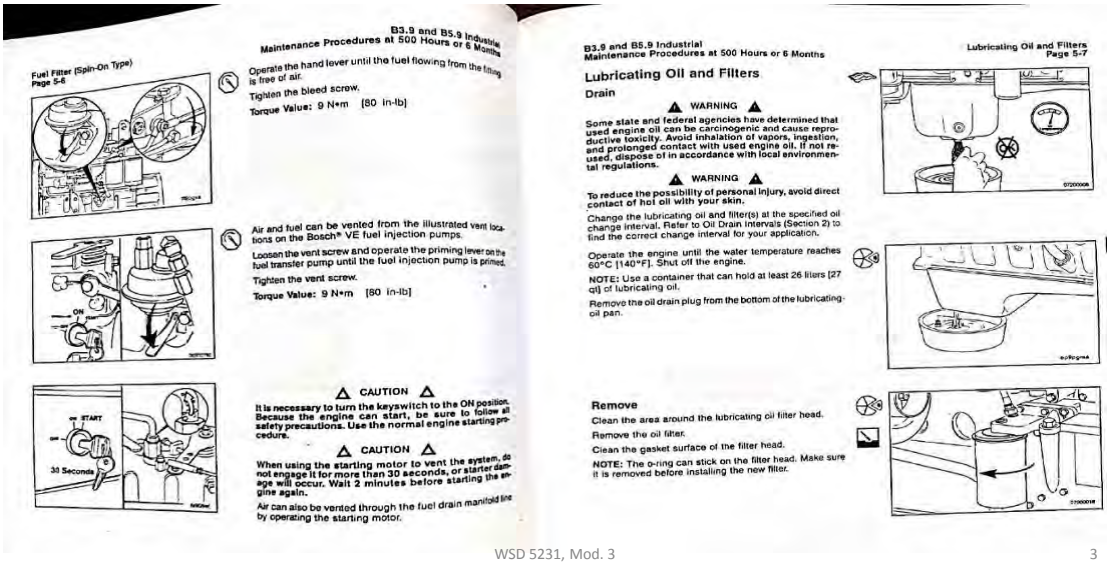
O&M Manual & Specification

Introduction of manufacturer's O&M manual

Depending upon the power rating, design and manufacturer, different generators may have different flow of maintenance. So O&M manual of each device must always be available at the site.

You have to keep O&M Manual of **YOUR** Generator with you

Introduction of manufacturer's O&M manual



B3.9 and B5.9 Industrial
Maintenance Procedures at 500 Hours or 6 Months

Fuel Filter (Spin-On Type)
Page 5-6

Operate the hand lever until the fuel flowing from the fitting is free of air.

Tighten the bleed screw.

Torque Value: 9 N•m [80 in-lb]

Air and fuel can be vented from the illustrated vent locations on the Bosch® VE fuel injection pumps.

Loosen the vent screw and operate the priming lever on the fuel transfer pump until the fuel injection pump is primed.

Tighten the vent screw.

Torque Value: 9 N•m [80 in-lb]

⚠ CAUTION ⚠

It is necessary to turn the keyswitch to the ON position. Because the engine can start, be sure to follow all safety precautions. Use the normal engine starting procedure.

⚠ CAUTION ⚠

When using the starting motor to vent the system, do not engage it for more than 30 seconds, or starter damage will occur. Wait 2 minutes before starting the engine again.

Air can also be vented through the fuel drain manifold line by operating the starting motor.

B3.9 and B5.9 Industrial
Maintenance Procedures at 500 Hours or 6 Months

Lubricating Oil and Filters
Page 5-7

Lubricating Oil and Filters

Drain

⚠ WARNING ⚠

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

⚠ WARNING ⚠

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

Change the lubricating oil and filter(s) at the specified oil change interval. Refer to Oil Drain Intervals (Section 2) to find the correct change interval for your application.

Operate the engine until the water temperature reaches 60°C [140°F]. Shut off the engine.

NOTE: Use a container that can hold at least 26 liters [27 qt] of lubricating oil.

Remove the oil drain plug from the bottom of the lubricating oil pan.

Remove

Clean the area around the lubricating oil filter head.

Remove the oil filter.

Clean the gasket surface of the filter head.

NOTE: The o-ring can stick on the filter head. Make sure it is removed before installing the new filter.

Specifications

Example: Generator at Aljazari Academy

GENERATING SET MODEL (PZ65)		
Output Ratings	**Prime**	**Standby**
380-415 V, 3 ph, 50 Hz, 1500 rpm	60 KVA	66 KVA
	48 KW	53 KW

Specifications

ALTERNATOR DATA	
Make	Stamford
Model	**UC224E**
No. of bearings	1
Insulation class	H
Total Harmonic Content	at no load <3% - on load <2%
Wires	12
Ingress Protection	IP23
Excitation System	SHUNT
Winding Pitch	2/3 (wdg 6)
AVR Model	R220
Overspeed	2250 mn^{-1}
Voltage Regulation (steady)	± 0.5%
Short Circuit Capacity	-

CONTROL PANEL	
Make	Deep Sea
Model	**7120**

The **DSE7120** is an Auto Start Control Module for single genset applications. It includes a backlit LCD display which clearly shows the status of the engine all the times. This module can either be programmed using the front panel or by using the DSE configuration suite PC software.

Metering and Alarm indications:

- Generator frequency
- Underspeed, Overspeed
- Generator volts (L-L, L-N)
- Generator current
- Engine oil pressure
- Engine coolant temperature
- Fuel level (Warning or shutdown) - Optional
- Hours run counter
- Battery volts
- Fail to start/stop
- Emergency stop
- Failed to reach loading voltage/frequency
- Charge fail
- Loss of magnetic pick-up signal - Optional
- Low DC voltage
- CAN diagnostics and CAN fail/error

Specifications

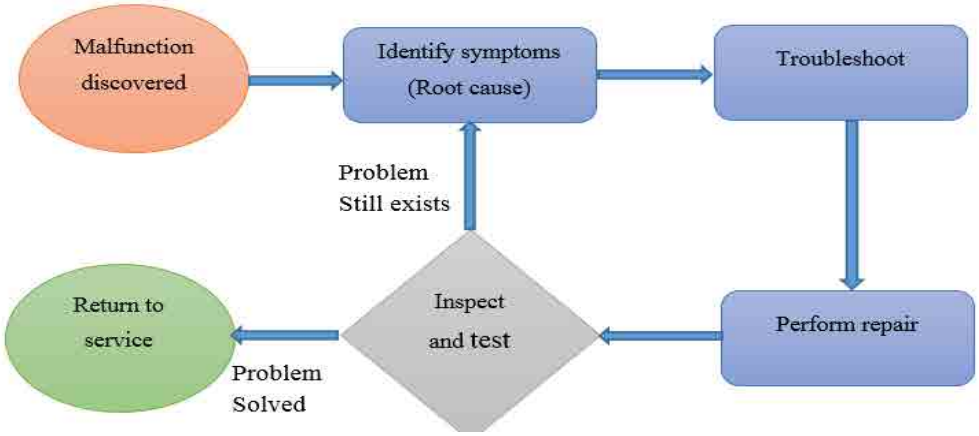
ENGINE / TECHNICAL DATA

Ratings at 0.8 Power Factor

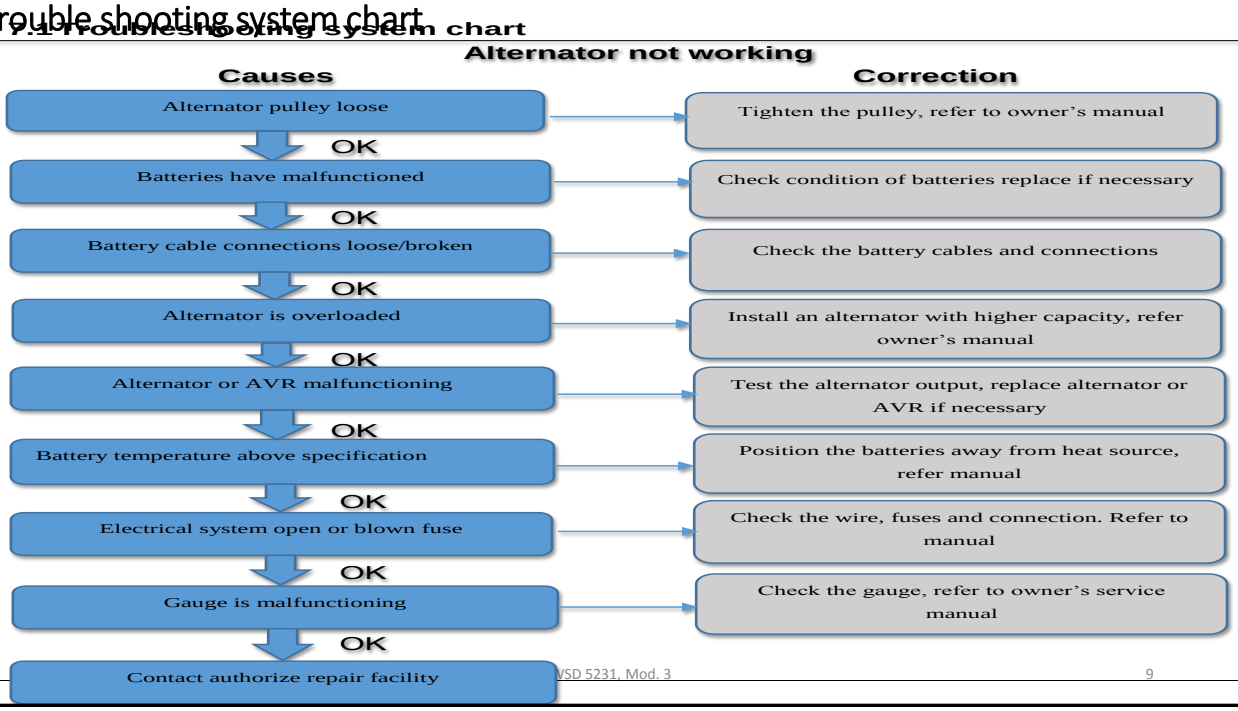
	50Hz & 1500rpm		60Hz & 1800rpm	
	Prime	**Standby**	**Prime**	**Standby**
Engine Make	Perkins			
Engine Model	1103A-33TG2			
Governing Type	Mechanical			
Number of Cylinders	3			
Cylinder Arrangement	Vertical in line			
Bore and Stroke mm	105 x 127			
Displacement / Cubic Capacity litres	3.3			
Induction System	Turbocharged			
Cycle	4 stroke			
Combustion System	Direct Injection			
Compression Ratio	17.25:1			
Rotation	Anti-clockwise, viewed from flywheel			
Cooling System	Water - cooled			
Gross Engine Power kW (hp)	55 (73.8)	60.5 (81.1)	63.3 (84.9)	69.6 (93.3)
Fuel Consumption @ 50% load L/hr	7.2	-	8.8	-
@ 75% load L/hr	10.4	-	12.5	-
@ 100% load L/hr	13.9	15.4	16.6	18.2
Total Lubrication System Capacity litres	7.9	7.9	7.9	7.9
Total Coolant Capacity (inc. radiator) litres	10.2	10.2	10.2	10.2
Exhaust Temperature: °C	557	571	534	564
Radiator Cooling Air Flow (Min): m^3/sec	1.48	1.48	1.85	1.85
Combustion Air Flow: m^3/min	3.8	3.9	4.7	4.9
Exhaust Gas Flow: m^3/min	10.1	10.4	11.8	12.5
Fuel Tank Capacity: litres	87	87	87	87

Troubleshooting

General Repair Process

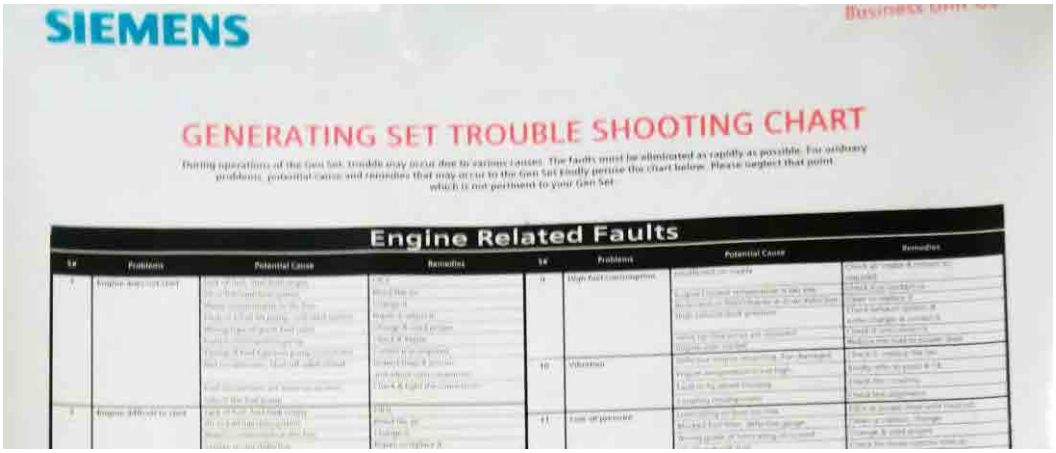


Trouble shooting system chart



Possible Fault Situation

Many faults can be occurred due to over use of generators,
in addition to the user manual, troubleshooting charts are also provided by the manufacturer i.e. M/S Siemens for guidance in possible fault situation.



Possible Fault Situation

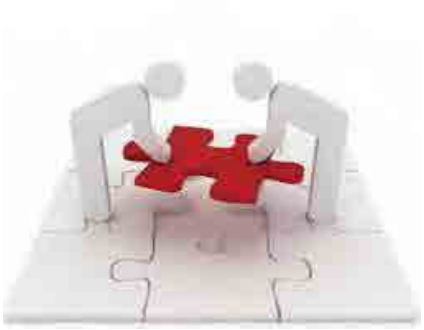
Engine Relate Faults			
Sr. #	**Problem**	**Potential Cause**	**Remedies**
1	Engine does not start	Lack of fuel., Fuel tank empty	Fill it
		Air in fuel injection system	Bleed the air
		Check Battery with Multi-meter	Replace or Charge battery
		Water contaminants in the fuel	Change it
		Fault in the fuel lift pump, cold stat system	Repair and adjust it
		Wrong type of grade fuel used	Change & use proper
		Fault in fuel injection pump	Check & repair
		Timing of fuel injection pump is incorrect	Correct is as required
		Bad compression, Shut-off valve closed	Inspect rings & pistons and adjust valve clearances
		Fuel connections are loose on suction side of the fuel pump	Check & tight the connections
2	Engine difficult to start	Lack of fuel., Fuel tank empty	Fill it
		Air in fuel injection system	Bleed the air
		Water contaminants in the fuel	Change it
		Starter motor defective	Repair or replace it
		Restriction in filter/ cleaner or in air induction system	clean or replace it
		Restriction in fuel vent	Remove & clean
		Restriction in exhaust pipe	Remove & clean exhaust system

Possible Fault Situation

Alternator Related Faults			
Sr. #	**Problem**	**Potential Cause**	**Remedies**
1	If Generator voltage below 400V & not adjustable via potentiometer	Drive speed too low	Check speed control of drive engine
		Voltage regulator defective	Replace voltage
2	Generator voltage too low (say less than 100V)	Interuption of excitor circuit	Tighten connections according to connection diagram
		Surge supressor faulty	Replace the supressor
		Rotating rectifier faulty	Repair the diaodes of the rectifier
3	If Generator voltage above 450 V & not adjustable via potentiometer	Drive spped too high	Check engine speed and adjust it to 1500 rpm
		Interruption of reference valve of AVR	Check AVR Connections
		Voltange regulator defective	Replace voltage regulator

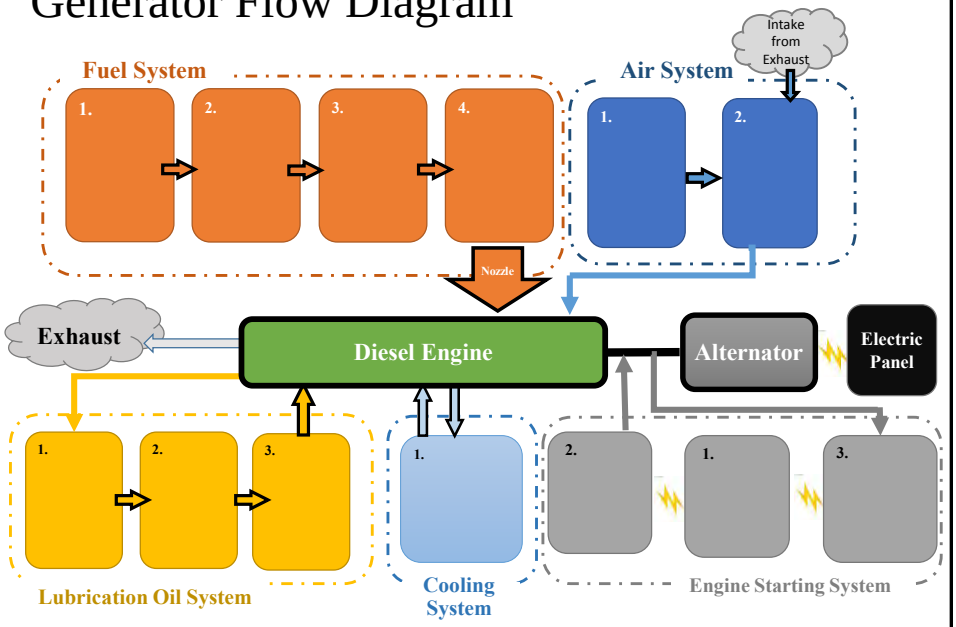
Wrap-up

- Things to take home…
- Generators drive your Operation.
- Always do a root cause analysis
- Repair is not preventive maintenance
- Keep records, always !!!



Generator Flow Diagram

EC-M2-01



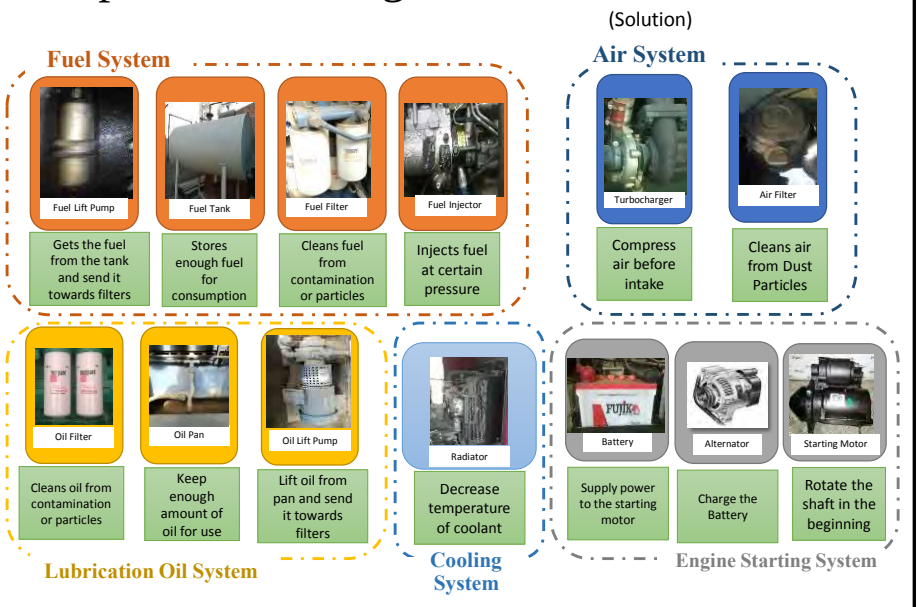
Name of Participant: _____

08/12/17

Components for Engine

EC-M2-02

(Solution)



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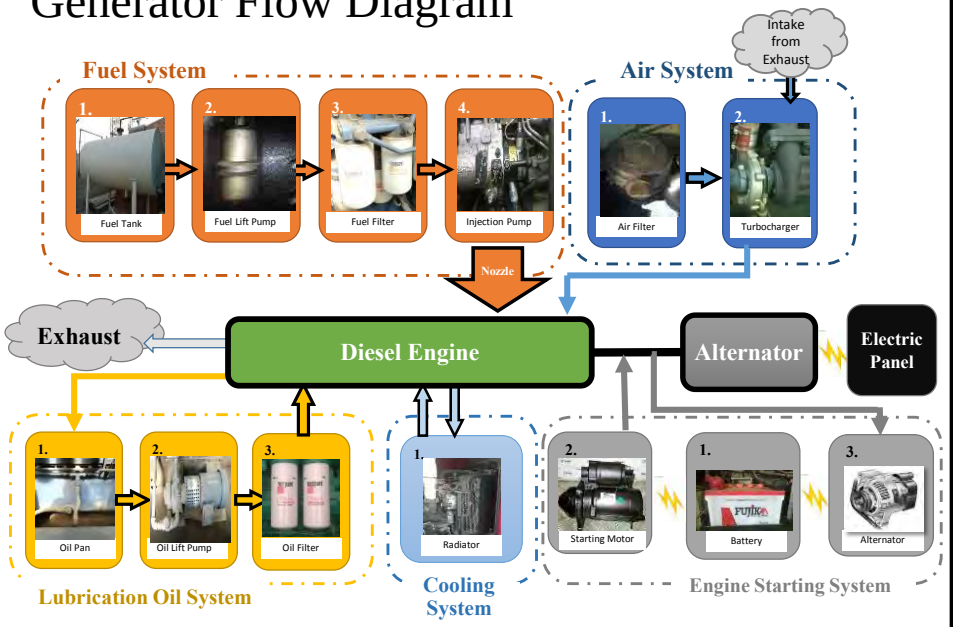
Generator Flow Diagram

EC-M2-03



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Maintenance Interval Schedule
(Sample for Practice)

Daily

- Alternator and Fan Belts – Inspect/Adjust/Replace
- Cooling System Coolant Level – Check
- Driven Equipment – Check
- Engine Oil Level – Check
- Fuel System Primary Filter/Water Separator – Drain
- Walk Around Inspection

Every 50 Service Hours or Weekly

- Fuel Tank Water and Sediment – Drain

Every 500 Service Hours or 1 Year

- Battery Electrolyte Condition & Level – Check
- Engine Air Cleaner Element – Clean/Replace
- Engine Oil and Filter – Change
- Fuel System Filter Element - Replace
- Hoses and Clamps – Inspect/Replace

Every 1000 Service Hours or 1 Year

- Engine Valve Lash – Inspect/Adjust

Every 2000 Service Hours or 1 Year

- Alternator – Inspect
- Engine Mounts – Inspect
- Starting Motor – Inspect

Every 2 Year

- Cooling System Coolant – Change

Generaotr Annual Maintenace Plan (Sample) -Year 2017-

Legend : Plan "●", Done "✓"

First Setting for Trial Activity

Average Operation Time per day	5	hours/day
Average Operation Time per month (※30days)	150	hours/month

※Days for each month are considered as 30days for ease.

Item	2017	2018									
	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Operation Hours of the Month	150	150	150	150	150	150	150	150	150	150	150	150
Total Operation Hours	**150**	**300**	**450**	**600**	**750**	**900**	**1050**	**1200**	**1350**	**1500**	**1650**	**1800**

Item	Required maintenance cycle	Product to be required	DEC		JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV	
			Plan	Done	Plan	Done	Plan	Done	Plan	Done	Plan	Done	Plan	Done	Plan	Done	Plan	Done	Plan	Done	Plan	Done	Plan	Done	Plan	Done
Fuel Tank Water and Sediment Drain	Every 50 hours	None	●		●		●		●		●		●		●		●		●		●		●		●	
Battery Electrolyte Level – Check	Every 500 hours	**Electrolyte**							●																	
Engine Air Cleaner Element – Clean/Replace	Every 500 hours	**Air Cleaner Element**							●																	
Engine Oil and Filter – Change	Every 500 hours	**Engine Oil Filter**							●																	
Fuel System Filter Element - Replace	Every 500 hours	**Fuel Filter**							●																	
Hoses and Clamps – Inspect/Replace	Every 500 hours	**Hoses, Clamps**							●																	
Engine Valve Lash – Inspect/Adjust	Every 1000 hours														●											
Alternator – Inspect	Every 2000 hours																									
Engine Mounts – Inspect	Every 2000 hours																									
Starting Motor – Inspect	Every 2000 hours																									
Cooling System Coolant – Change	Every 2 Years																									

12/08/2017

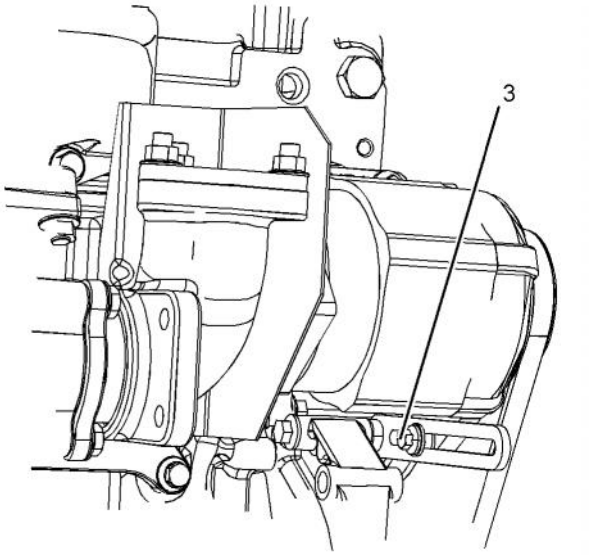


Illustration 31 g03716558

2. loosen the link bolt (3). Move the alternator in order to increase or decrease the belt tension. Tighten the alternator pivot bolt and the link bolt to 22 N·m (16 lb ft).(1).

Replacement

Refer to the Disassembly and Assembly Manual for the installation procedure and the removal procedure for the belt.

i02322315

Battery - Replace

⚠ WARNING

Batteries give off combustible gases which can explode. A spark can cause the combustible gases to ignite. This can result in severe personal injury or death.

Ensure proper ventilation for batteries that are in an enclosure. Follow the proper procedures in order to help prevent electrical arcs and/or sparks near batteries. Do not smoke when batteries are serviced.

⚠ WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Switch the engine to the OFF position. Remove all electrical loads.

2. Turn off any battery chargers. Disconnect any battery chargers.

3. The NEGATIVE "-" cable connects the NEGATIVE "-" battery terminal to the NEGATIVE "-" terminal on the starting motor. Disconnect the cable from the NEGATIVE "-" battery terminal.

4. The POSITIVE "+" cable connects the POSITIVE "+" battery terminal to the POSITIVE "+" terminal on the starting motor. Disconnect the cable from the POSITIVE "+" battery terminal.

Note: Always recycle a battery. Never discard a battery. Dispose of used batteries to an appropriate recycling facility.

5. Remove the used battery.

6. Install the new battery.

Note: Before the cables are connected, ensure that the engine start switch is OFF.

7. Connect the cable from the starting motor to the POSITIVE "+" battery terminal.

8. Connect the NEGATIVE "-" cable to the NEGATIVE "-" battery terminal.

i02747977

Battery Electrolyte Level - Check

When the engine is not run for long periods of time or when the engine is run for short periods, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing. If batteries are correctly charged, the ammeter reading should be very near zero, when the engine is in operation.

⚠ WARNING

All lead-acid batteries contain sulfuric acid which can burn the skin and clothing. Always wear a face shield and protective clothing when working on or near batteries.

1. Remove the filler caps. Maintain the electrolyte level to the "FULL" mark on the battery.

   If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.

2. Check the condition of the electrolyte with a suitable battery tester.

3. Install the caps.

4. Keep the batteries clean.

   Clean the battery case with one of the following cleaning solutions:

   - Use a solution of 0.1 kg (0.2 lb) baking soda and 1 L (1 qt) of clean water.
   - Use a solution of ammonium hydroxide.

   Thoroughly rinse the battery case with clean water.

i02323088

Battery or Battery Cable - Disconnect

⚠ WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Turn the start switch to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.

2. Disconnect the negative battery terminal. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, two negative connection must be disconnected.

3. Remove the positive connection.

4. Clean all disconnected connection and battery terminals.

5. Use a fine grade of sandpaper to clean the terminals and the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to not fit correctly. Coat the clamps and the terminals with a suitable silicone lubricant or petroleum jelly.

6. Tape the cable connections in order to help prevent accidental starting.

7. Proceed with necessary system repairs.

8. In order to connect the battery, connect the positive connection before the negative connector.

i05901701

Cooling System Coolant (Commercial Heavy-Duty) - Change

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to Local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Clean the cooling system and flush the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming is observed.
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

Cleaning the Primary Air Cleaner Elements

NOTICE
Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow up the pleats and down the pleats from the inside of the filter element. Take extreme care in order to avoid damage to the pleats.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

Refer to the OEM information in order to determine the number of times that the primary filter element can be cleaned. When the primary air cleaner element is cleaned, check for rips or tears in the filter material. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

NOTICE
Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the primary air cleaner elements before cleaning. Inspect the air cleaner elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged air cleaner elements.

There are two common methods that are used to clean primary air cleaner elements:

- Pressurized air
- Vacuum cleaning

Pressurized Air

Pressurized air can be used to clean primary air cleaner elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

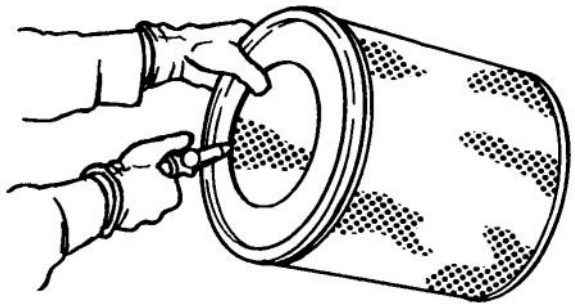


Illustration 38 g00281692

Note: When the primary air cleaner elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter in order to help prevent damage to the paper pleats. Do not aim the stream of air directly at the primary air cleaner element. Dirt could be forced further into the pleats.

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Vacuum Cleaning

Vacuum cleaning is a good method for cleaning primary air cleaner elements which require daily cleaning because of a dry, dusty environment. Cleaning with pressurized air is recommended prior to vacuum cleaning. Vacuum cleaning will not remove deposits of carbon and oil.

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Inspecting the Primary Air Cleaner Elements

Illustration 39 g00281693

Inspect the clean, dry primary air cleaner element. Use a 60 watt blue light in a dark room or in a similar facility. Place the blue light in the primary air cleaner element. Rotate the primary air cleaner element. Inspect the primary air cleaner element for tears and/or holes. Inspect the primary air cleaner element for light that may show through the filter material. If it is necessary in order to confirm the result, compare the primary air cleaner element to a new primary air cleaner element that has the same part number.

Do not use a primary air cleaner element that has any tears and/or holes in the filter material. Do not use a primary air cleaner element with damaged pleats, gaskets or seals. Discard damaged primary air cleaner elements.

i02152042

Engine Air Cleaner Element (Single Element) - Inspect/ Replace

Refer to Operation and Maintenance Manual, “Engine Air Cleaner Service Indicator-Inspect”.

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent airborne debris from entering the air inlet.

NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

A wide variety of air cleaners may be installed for use with this engine. Consult the OEM information for the correct procedure to replace the air cleaner.

i01909507

Engine Air Cleaner Service Indicator - Inspect

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The differential gauge for inlet air pressure displays the difference in the pressure that is measured before the air cleaner element and the pressure that is measured after the air cleaner element. As the air cleaner element becomes dirty, the pressure differential rises. If your engine is equipped with a different type of service indicator, follow the OEM recommendations in order to service the air cleaner service indicator.

The service indicator may be mounted on the air cleaner element or in a remote location.

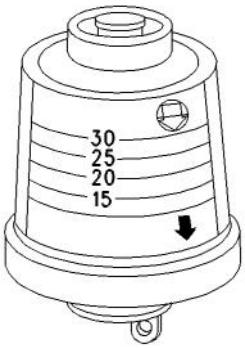


Illustration 40 g00103777
Typical service indicator

Observe the service indicator. The air cleaner element should be cleaned or the air cleaner element should be replaced when one of the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.

Test the Service Indicator

Service indicators are important instruments.

- Check for ease of resetting. The service indicator should reset in less than three pushes.
- Check the movement of the yellow core when the engine is accelerated to the engine rated speed. The yellow core should latch approximately at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the yellow core does not latch at the greatest vacuum, the service indicator should be replaced. If the new service indicator will not reset, the hole for the service indicator may be restricted.

The service indicator may need to be replaced frequently in environments that are severely dusty.

i01941505

Engine Ground - Inspect/Clean

Inspect the wiring harness for good connections.

Perkins use the starter motor in order to ground the engine. Check the connection on the starter motor at every oil change. Ground wires and straps should be combined at engine grounds. All grounds should be tight and free of corrosion.

- Clean the grounding stud on the starter motor and the terminals with a clean cloth.
- If the connections are corroded, clean the connections with a solution of baking soda and water.
- Keep the grounding stud and the strap clean and coated with suitable grease or petroleum jelly.

i02323089

Engine Mounts - Inspect

Note: The engine mounts may not have been supplied by Perkins. Refer to the OEM information for further information on the engine mounts and the correct bolt torque.

Inspect the engine mounts for deterioration and for correct bolt torque. Engine vibration can be caused by the following conditions:

- Incorrect mounting of the engine
- Deterioration of the engine mounts
- Loose engine mounts

Any engine mount that shows deterioration should be replaced. Refer to the OEM information for the recommended torques.

i05909059

Engine Oil Level - Check

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

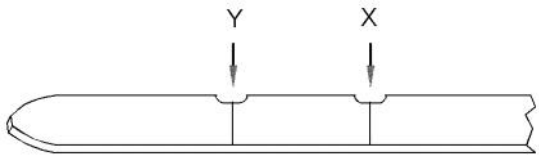


Illustration 41 g01165836
(Y) “Min” mark. (X) “Max” mark.

Illustration 42 g02173847
(L) “Min” mark. (H) “Max” mark.

NOTICE
Perform this maintenance with the engine stopped.

Note: Ensure that the engine is either level or that the engine is in the normal operating position in order to obtain a true level indication.

Note: After the engine has been switched OFF, wait for 10 minutes in order to allow the engine oil to drain to the oil pan. Then, check the oil level.

Name of Participant: _____

Q1: Write down the procedure of cleaning air cleaner element in your own words

Q2: Write down the procedure of checking electrolyte level and condition of battery in your own words

Operations and Maintenance of Electrical Equipment

Application of 5S

Quality Tool for Operational Excellence

Objectives of Application of 5S

❖***Application of 5S for enhancing:***

- Productivity
- Efficiency
- Quality
- Safety



3/30

What is 5S?

Seiri (Sort)	Distinguish between necessary and unnecessary items.
Seiton (Set in order)	Enforce the dictum 'a place for everything and everything in its place'.
Seiso (Shine)	Clean up the demarcated area.
Seiketsu (Standardize)	Maintain and monitor adherence to the first three Ss.
Shitsuke (Sustain)	Follow the rule to keep the workplace 5S-right. Hold the gain.

4/22

5S – A Quality, Productivity, Efficiency and Safety Tool

- 5S is an approach to eliminate waste, organize work place to save time and effort to achieve operational efficiency.
- Implementation of 5S improves operational quality and efficiency.
- It enhances safety by reducing hazards, which may occur due to an unorganized work place.

1. Sort (Seiri)

- Necessary items are separated from unnecessary items and removed.
- *Unnecessary items' accumulation makes it difficult to find and keep important items organized.*
- Red tag campaign is conducted to evaluate items based on their usefulness and frequency of use.
- Items can include obsolete equipment and inventory, broken tools, scrap, old files, etc.
- Safety and productivity are improved as a result of an organized work place.

1. Sort (Seiri) For wavering items

- Place un-necessary items in the red tag area
- Allow course participants to re-evaluate the needed items
- At the end of evaluation, required items should be returned to proper area

PRIORITY	FREQUENCY OF USE	HOW TO USE
Low	Less than once per year Once per year	Discard Store away from the workplace
Average	Once per month Once per week	Store together
High	Once per day	Locate at the workplace

7/22

2. Set-in-order (Seiton)

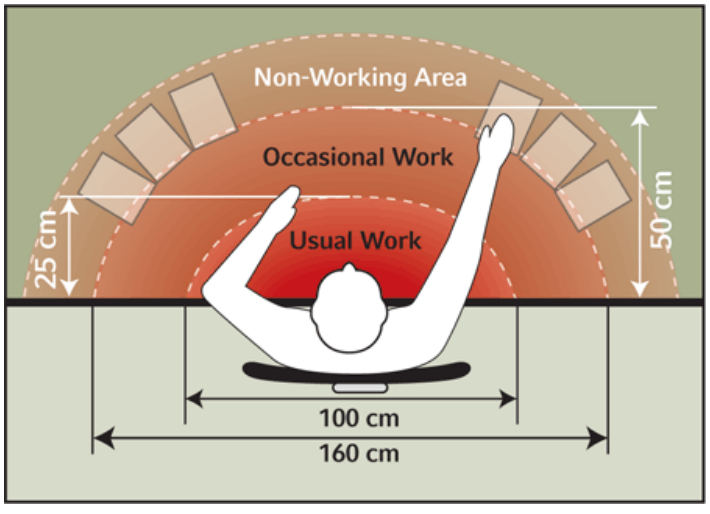
- It involves setting of necessary items, which are always located in logically predetermined locations.
- Based on the inventory classification of the red tag campaign, items are placed in locations based on frequency of use.
- Frequently used items are placed at or near the work place.
- Infrequently used items are stored in store.
- Items in store would help employees save time, otherwise wasted in trying to locate scattered items.

8/22

3. Shine (Seiso)

- It is a regular cleaning activity at and near the work area.
- Removing unnecessary stickers, posters, pictures and other items.
- During operations and maintenance **ergonomically** establishing the positions for tools and equipment.
- Continuously achieve better level of organized and efficient work place through brainstorming.

3. Shine (Seiso)



4. Standardize (Seiketsu)

- The goal of this step is to set a standard work place (organized)
- This is achieved by providing visual labels and signs
- Work place is marked and labeled so that organization is made simple and easy
- Organized and marked tool boards etc.

11/22

5. Sustain (Shitsuke)

- It involves developing habits to implement the 5S philosophy on an ongoing basis.
- If 5S is to be successful, a regular appraisal of the electrical panel is required.
- This ensures the focus remains on maintaining the electrical panel.
- It is a housekeeping and a structured program.
- **5S activity is conducted systematically and regularly.**
- **5S activity is tracked through a visual control board.**

12/22

Before

After

WASA Outfall Workshop, Lahore

Before

After

WASA South Yard, Lahore

Before

After

SCBA equipment was buried under this

15/25

16/25

5S is a continuous improvement tool !!!

- Create necessary documents or forms to support/optimize your operations
  - ✓ Process flow charts
  - ✓ Contact lists
  - ✓ Emergency response procedures
  - ✓ SOPs
  - ✓ Post job instructions
  - ✓ Label equipment for operators

17/25

Panel without Labels

18/25

Panel with Labels

19/25

Panel with Labels

20/25

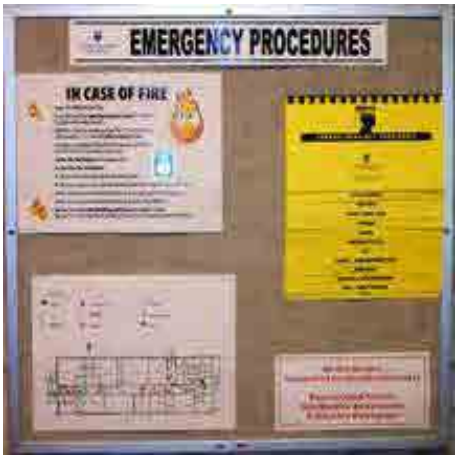
Panel with Instructions

21/25

Panel with Drawings

22/25

Post important forms here !



Emergency Procedures

Emergency Contact List

25/25

5S Activity Track Sheet

January, 2017 Date (activity performed):

	Quantity	*Notes*
Items Sorted		
Items Stored		
Items Discarded		
Total Items		

February, 2017 Date (activity performed):

	Quantity	*Notes*
Items Sorted		
Items Stored		
Items Discarded		
Total Items		

March, 2017 Date (activity performed):

	Quantity	*Notes*
Items Sorted		
Items Stored		
Items Discarded		
Total Items		

April, 2017 Date (activity performed):

	Quantity	*Notes*
Items Sorted		
Items Stored		
Items Discarded		
Total Items		

May, 2017 Date (activity performed):

	Quantity	*Notes*
Items Sorted		
Items Stored		
Items Discarded		
Total Items		

June, 2017 Date (activity performed):

	Quantity	*Notes*
Items Sorted		
Items Stored		
Items Discarded		
Total Items		

Device Inspection Sheet

Evaluation Criteria
✓: Good ×: No care at all or need to be newly installed
△: Need to be improved —: Not available to be checked

Sr. No.	Site /Pump Name	Inspection Date	Continuity Test of components (Using Clamp Meter)									Relays Adjustments					
			Circuit Breakers					Magnetic Contactor			Fuse	Over/Under Voltage Relay			Over Current (Thermal) Relay		Y-Δ Timer
			MCCB	MCB 1	MCB 2	MCB 3	MCB 4	K1	K2	K3		Under Voltage Tripping Function	Over Voltage Tripping Function	±10% of rated voltage of motor	Tripping Function	Value Set	Not less than 5 seconds
1	Disposal Station, Chungi # 9, Panel # 2	3/28/2017	✓	✓	✓	✓	✓	✓	✓	✓	-	×	×	-	×	-	✓
2	Disposal Station, Chungi # 9, Panel # 4	3/28/2017	-	×	✓	✓	✓	✓	✓	×	-	×	×	-	×	-	✓
3	Disposal Station, Chungi # 9, Panel # 7	3/28/2017	✓	×	△	✓	✓	✓	✓	✓	-	×	×	-	×	-	✓
4	Disposal Station, Chungi # 9, Panel # 8	3/28/2017	✓	✓	✓	✓	✓	✓	✓	✓	-	×	×	-	✓	-	✓
5	Disposal Station, Chungi # 9, Panel # 11	3/28/2017	✓	△	△	△	✓	✓	✓	✓	-	×	×	-	×	-	✓
Total Numbers of items required to be replaced*			0	3	2	1	0	0	0	1	-	5			4		0

- Remarks -
MCB 4 of panel number 2 was malfunctioned and already replaced

* All components should be purchased as per required specification of each panel according to the installed motor

Preventive Maintenance Sheet for Electrical Facility

Site Name :

Sub Division :

Motor Specification				
Rated Capacity	Rated Voltage	Rated Ampere	Efficiency	Power Factor
(kW)	(V)	(A)	-	-

Evaluation Criteria
✓: Good
×: No care at all or need to be newly installed
△: Need to be improved
—: Not available to be checked

No.	Date	Weather	Approved by	Inspected by	Preventive Maintenance																	Evaluation
					Visual Condition/Cleanliness						Bolt Tightening	Voltage by Clamp Meter (V)			Ampere by Clamp Meter (A)			Insulation Resistance (MΩ)			Vibration	Temperature	
					Cleanliness	Neatness of Cabling	Cable Color	Cable/ wire Label	Proper Sealing	Terminal Cover		RY	YB	BR	R	Y	B	$\frac{U1}{U2}$	$\frac{V1}{V2}$	$\frac{W1}{W2}$	$\frac{Upper\ Bearing}{Lower\ Bearing}$		
1																							

Preventive Maintenance Sheet for Electrical Facility

Sub Division :	**Motor Specification**			**Rated Capacity (kW/HP)**	
Site Name:	**Rated Voltage**	**Rated Ampere**	**Efficiency**	**Power Factor**	**RPM**
Equipment Name:	**(V)**	**(A)**	**-**	**-**	

Date						
Inspected By						
Weather						
Bolt Tightening						
Insulation Resistance (MΩ)	U1-E	U2-E				
	V1-E	V2-E				
	W1-E	W2-E				
	U1-V1	U2-V2				
	V1-W1	V2-W2				
	W1-U1	W2-U2				
Voltage by Clamp Meter (V)	RY					
	YB					
	BR					
Ampere by Clamp Meter (A)	R					
	Y					
	B					
Power Factor						
Vibration	Upper Bearing	Lower Bearing				
Revolution Per Minute (RPM)						
Temperature	Upper Bearing	Lower Bearing				
	Shaft					

Reference for Insulation Resistance Value: Good → more than 1.0MΩ

Need to Adjust, Clean,Care → 1.0MΩ ~ 0.4 Need to repair immediately →less than 0.4MΩ

- Remarks -

Check List of Standard Operation Procedure for Electrical Facility

Approved by :

Inspected by :

Motor Specification: **Rated Capacity (kW/HP) _____**

Rated Voltage (V) _____Rated Current(A) _____

Efficiency_____Power Factor_____RPM_____

Evaluation Criteria

✓: Good ×: No care at all or need to be newly installed

△: Need to be improved —: Not available to be checked

Sr. No.	Site/Pump Name	Inspection Date	Inspection Items for Electrical Panel Condition															
			Document			Visual (Outside)						Visual (Inside)				Operation		
			Operation Record	Drawings	Vender Manual	Identification of Lamp/Switch	Status/ Fault Indication Lamps	Ampere Meter	Voltage Meter	Status Selector Switch		Cleanliness	Intrusion Path	Bypass-Circuit	Neatness of cabling	How to operate changeover switch	Frequency of Start/Stop	
			Compare with the sample	Pump installation, electrical line diagram	Pump/ Panel devices	all lamps /switches have name tag	all lamps are visibly bright enough	Proper functioning and zero adjustment	Proper functioning and zero adjustment	Ampere	Voltage	No dust, sand, spider's nest, insect, small animals	No hole/ crack to let foreign matters come in	No bypass / burnt mark		Turn off by breaker or switch first.	Maximum 2-3 times/ hour	
1																		
2																		
3																		

- Remarks -

Check List of Standard Operation Procedure for Electrical Facility

Evaluation Criteria
✓ : Good ×: No care at all or need to be newly installed
△: Need to be improved —: Not available to be checked

			Document			Visual (Outside)						Visual (Inside)				Operation	
			Operation Record	Drawings	Vender Manual	Identifications of Lamp/Switch	Status/Fault Indication Lamps	Ampere Meter	Voltage Meter	Status Selector Switch		Cleanliness	Intrusion Path	Bypass-Circuit	Neatness of cabling	How to operate changeover switch	Frequency of Start/Stop
			Compare with the sample	Pump installation, electrical line diagram	Pump/ Panel devices	all lamps /switches have name tag	all lamps are visibly bright enough	Proper functioning and zero adjustment	Proper functioning and zero adjustment	Ampere	Voltage	No dust, sand, spider's nest, insect, small animals	No hole/crack to let foreign matters come in	No bypass / burnt mark		Turn off by breaker or switch first.	Maximum 2-3 times/hour
1	Disposal Station, Chungi # 9, Panel # 2	3/28/2017	✓	△	×	✓	✓	✓	-	✓	-	△	△	✓	✓	✓	✓
2	Disposal Station, Chungi # 9, Panel # 4	3/28/2017	✓	△	×	✓	✓	✓	-	△	-	△	△	△	△	✓	✓
3	Disposal Station, Chungi # 9, Panel # 7	3/28/2017	✓	△	×	✓	✓	△	-	△	-	△	△	✓	△	✓	✓
4	Disposal Station, Chungi # 9, Panel # 8	3/28/2017	✓	△	×	✓	✓	△	✓	△	-	✓	△	✓	✓	✓	✓
5	Disposal Station, Chungi # 9, Panel # 11	3/28/2017	✓	△	×	✓	**Off lamp is not working**	△	-	△	-	△	△	✓	✓	✓	✓
Total Numbers of items required to be replaced*							1			4							

- Remarks -
1. No lamp test was available so status of O/L Lamp can not be checked
2. Confirm that Current Transformers (CTs) are working fine before replacement of Ampere meter. In case of malfunctioning CT, please change CT first and if Ampere meter still not giving correct value then replace it.

Motor Specification:
Rated Capacity:
Rated Voltage (V) :
Rated Current(A) :
Efficiency:
Power Factor:
RPM:

Motor Specification:
Rated Capacity:
Rated Voltage (V) :
Rated Current(A) :
Efficiency:
Power Factor:
RPM:

* All components should be purchased as per required specification of each panel according to the installed motor

Device Inspection Sheet

Approved by :

Inspected by :

Motor Specification: **Rated Capacity (kW/HP) _____**

Rated Voltage (V) _____Rated Current(A) _____Efficiency_____

Power Factor_____RPM_____

Evaluation Criteria

✓: Good ×: No care at all or need to be newly installed

△: Need to be improved —: Not available to be checked

Sr. No.	Site /Pump Name	Inspection Date	Continuity Test of components (Using Clamp Meter)									Current Transformer			Relays Adjustments					
			Circuit Breakers					Magnetic Contactor			Fuse				Over/Under Voltage Relay			Over Current (Thermal) Relay		Y-Δ Timer
			MCCB	MCB 1	MCB 2	MCB 3	MCB 4	K1	K2	K3		CT1	CT2	CT3	Under Voltage Tripping Function	Over Voltage Tripping Function	±10% of rated voltage of motor	Tripping Function	Value Set	Not less than 5 seconds
1																				
2																				
3																				
4																				
5																				

- Remarks -

Fault Reporting and Maintenance Request Form

Name of Operator (reporting person):_____

Mobile No._____

Facility Location:_____

Date: _____ **Time:** _____

Site In-charge:_____

Is it an emergency: Yes/No

If yes, please follow the posted emergency reporting procedure

Fault Type

Electrical: Yes/No

Mechanical: Yes/No

Other: (Please describe)_____

Public Safety Related: Yes/No

If yes, follow emergency reporting procedures

Fault Details

_____

_____

Maintenance Request:

_____

_____

_____

Fault Reporting and Maintenance Request Form

Name of Operator (reporting person): Jawad Shahid

Mobile No. 033334445555

Facility Location: Aljazari Academy, Township, Lahore

Date: April 11, 2017 **Time:** 2:00 PM

Site In-charge: Muasb Uzair

Is it an emergency: Yes/No

If yes, please follow the posted emergency reporting procedure

Fault Type

Electrical: Yes/No

Mechanical: Yes/No

Other: (Please describe)_____

Public Safety Related: Yes/No

If yes, follow emergency reporting procedures

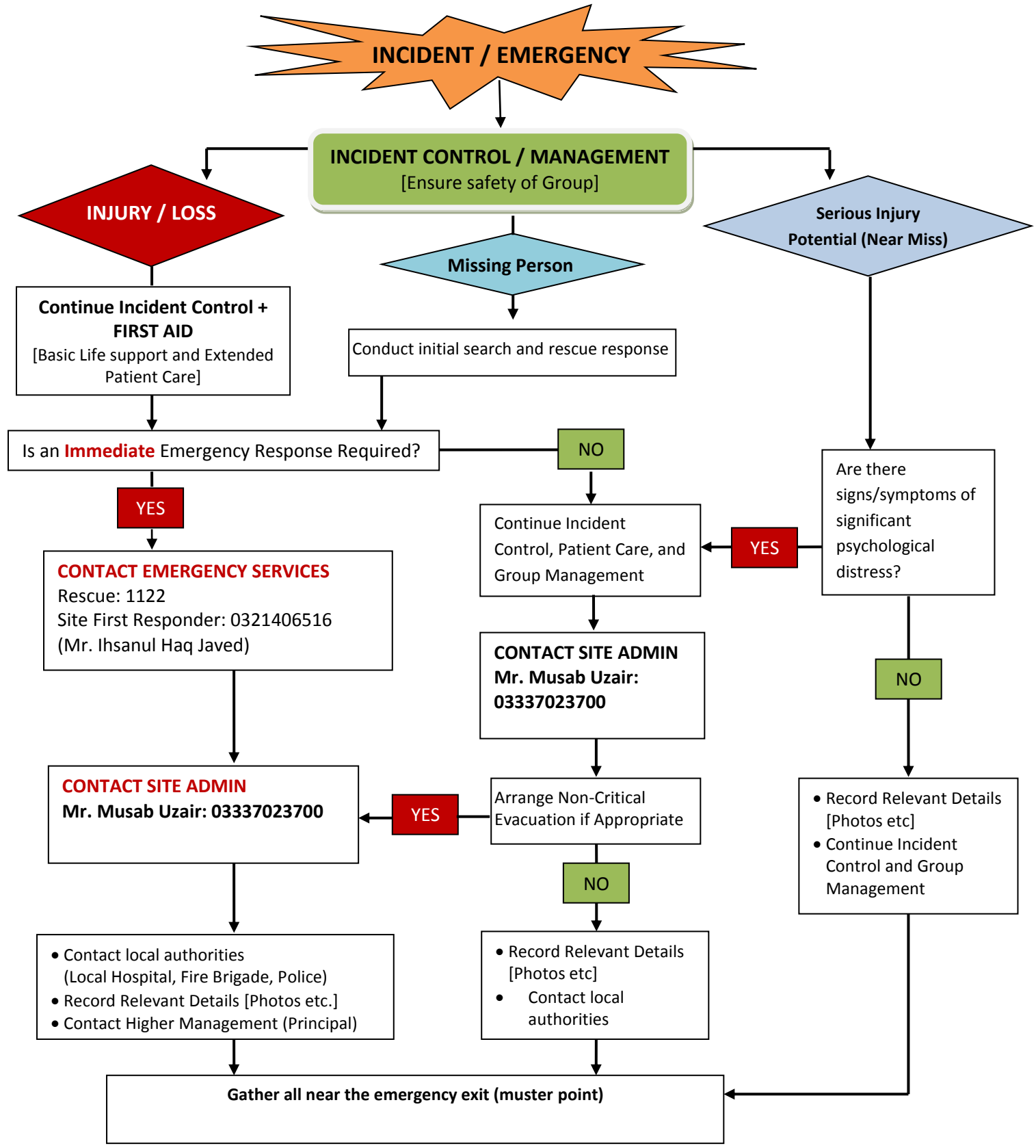
Fault Details

Control Panel is short circuited due to faulty insulation (wires), operator, property and general public are at risk of electric shock and fire.

Maintenance Request:

An Electrician is required onsite to ensure proper insulation and address the short circuit issue.

Incident / Emergency Response Flow Chart



Emergency Contact List

Name	Contact No.
First Responders **Mr. Ihsan Ul Haque Javed**	03214065716
Site Administrator Name **Mr. Musab Uzair**	03337023700
Fire Brigade	**16**, 9211280, 9200281, 9200282, 9200283
Rescue 1122	**1122**
Police Station Town Ship Lahore	0429262171, 03087771827
Police Station Green Town	04235118000, 35113868
Counter Terrorism Department	0800111111
Nearest Hospital	
Address: Ch. Rehmat Ali Trust Hospital (Next Door)	042 35154812
Jinnah Hospital Lahore	04235168660
CPO Lahore	042992100623
DIG Operations	0429920030
Bomb Disposal	04299212111, 0423752828

Operation and Maintenance of Electrical Equipment

Health Safety & Environment

Significance of HSE

O&M of Electrical Installations contains potential hazards which may cause:

- ❖ Human Death or Injury
- ❖ Time Loss
- ❖ Equipment Loss
- ❖ Environment Degradation

2

WASA Electrical Equipment

3

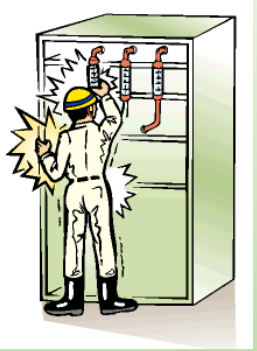
WASA Electrical Equipment

4

Electrical Hazards

What is a Hazard?

Situation that poses a level of threat to Life, Health, Property or Environment.



Electric shock

Electric fire

5

Hazards for Electrical Panel

Broken base plate

Lizard & Dust etc.

Exposed electrical parts

6

Hazards for Electrical Panel

Trip , Fall & electric shock

Wet & moist condition

7

Hazard Hunting & Job Safety Analysis

Hazard Hunting:

On-going process to identify & assess work place hazards, and propose control measures according to hierarchy of control

Job Safety Analysis:

Process of studying and recording each step of a job, identifying existing or potential hazards, and determining the best way to perform the job safely.

Based on four steps:

1.Selection of jobs for analysis

2.Breakup of selected job into steps

3.Identify hazards associated with each step

4.Eliminate or control the hazards

8

Probability

Extent to which a hazard may cause harm.

Probability	Rating	Comments
Frequent	5	Frequently at risk
Probable	4	Likely to cause harm
Occasional	3	Occasionally at risk
Possible/remote	2	Could cause harm, but is unlikely to
Improbable	1	Unlikely to cause harm.

9

Severity

Seriousness of harm.

Severity	Rating	Comments
Catastrophic	5	Death / destruction
Critical	4	Severe injury / equipment damage
Serious	3	Injury / equipment damage
Marginal	2	Minor Injury
Negligible	1	No Injury

10

Priority Level

Hazard =Probability x Severity

Probability	Severity	Priority level
2	3	6
2	2	4
3	1	3

Hazard Coding

Priority rating	Hazard Level	Hazard Code
11 – 25	High	H
5 – 10	Medium	M
1 - 4	Low	L

11

Electrical Safety

Steps to respond:

If you come across a person receiving an electric shock:

1. Disconnect electrical main supply
2. Protect yourself & anyone else in the vicinity
3. Move casualty to safe area
4. Call Rescue 1122
5. Perform CPR

12

Electrical Fire Safety

☠Do not use water to Extinguish electrical fire

13

Electrical Fire Safety

Plan for Fire Emergencies

- Allocate locations for emergency exits
- Allocate location of fire alarm and fire extinguishers
- Conduct electrical fire drills
- Identification of Electrical Fire Extinguisher (C or E class)
- Guide procedure to use the fire extinguisher

14

Electrical Safety & Control Measures

- Shut off main power supply before O & M
- No work alone policy
- Keep clear spacing & emergency exits Unblocked
- No Smoking policy
- Place trash in receptacles

15

Hazard control during operations & maintenance

1. **Elimination :** Remove unsafe conditions Turn off power supply
2. **Substitution:** Replacement of parts should be done as per generator O &M Manual
3. **Isolation:** Protection of generator from rain fall , provision of Fencing
4. **Engineering Control:** Install Earthing to prevent electric shock , Catalytic convertor
5. **Administrative Control:** Lock out / Tag out of faulty installation
6. **PPE:** Use PPE, wear insulation gloves , Shoes with insulated sole and toe protection

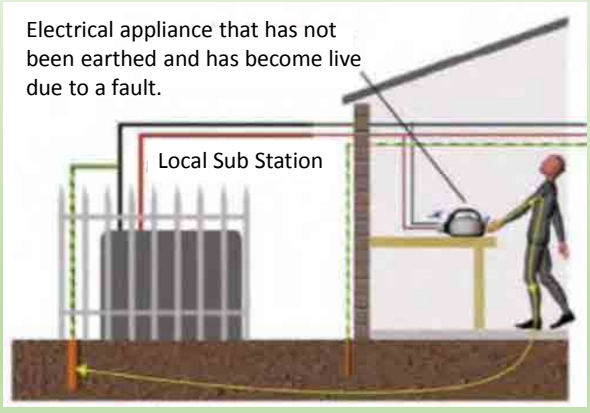
More Effective

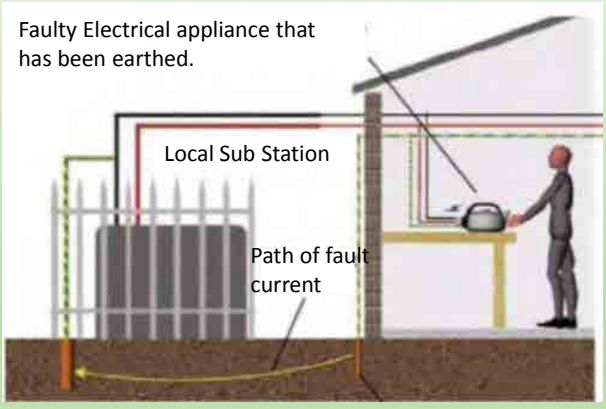
Less Effective

16

Electrical Safety & Control Measures

Grounding





17

Electrical Safety & Control Measures

Guarding

18

Electrical Safety of High Voltage Panels

- Trained & qualified high voltage electrical employee
- Shut off main power supply
- Free clear spacing
- No work alone policy
- Certified PPE
- Pre-inspection of tools
- Protective shield for live parts

19

Safety about Arcing & Flash

1. Check & Verify voltages on electrical contact points
2. Avoid using metal or conductive tools
3. Avoid pointing or placing metal tools near live contact points
4. Keep live electrical parts cover & close during O&M

20

Use of Personal Protective Equipment (PPE)

21

Low Voltage Rescue Kit

A safety kit for technician working on electrical installations, etc.

Following are the components of this kit:-

- Fire blanket
- Low voltage rescue crook
- Isolation tag
- Trauma dressing *
- High resolution torch
- Bag

*** Always examine expiry date before use.**

22

Ihsan ul Haque Javed
Sr. Instructor (HSE)
ihaque@urbanunit.gov.pk

23

Job Safety Analysis

Name: _____

Date: _____

Job:		
Sequence of Tasks	**Potential Hazards**	**Preventive Measures**

Hazard Identification of a Tube well room

Please go through the given picture of a Tube well, identify at least five hazards related to electrical installations, assess priority and propose action.


2
2
3
4
1
5

Name: _____ Date: _____

Sr#	Hazard	Priority (H/M/L)	Proposed Action	Due Date	Comment
1					
2					
3					
4					
5					

Name: _____ Date: _____

Sr #	Condition (Hazard)	Priority (H/M/L)	Proposed Action	Due Date	Comment
1	Obstruction to vacate area (Confined space)	H	i) Exit strategy ii) Obtain permit to work iii) Use of PPE iv) No work alone		
2	Missing warning signs & labeling of electrical installations	H	i) Posting of warning signs and labeling		
3	Storage of unnecessary items (Trip & Fall)	H	i) Removal of unnecessary items ii) Housekeeping		
4	Loose connection & unprotected live wires (Electrical shock & fire)	H	i) Provision of CO_2 fire extinguisher ii) Impart training on use of fire extinguisher iii) Record keeping of refilling		
5	Opening in wall (rodents & creepers)	M	Sealing of wall opening		
6	Electrical cable laying on floor (Electric shock, Trip & fall)	H	Provision of ducting insulation and Earthing of electrical installations		

Action Plan

Name of Participant: _____ Date of Training: _____

Name of Organization: _____

1. Please focus on and list up the any actions you can actually apply at your sites. It should NOT be like just saying "SOP" "Preventive Maintenance", Please write down the possible actions as detail as possible such as including device name.

Electrical Panel

Generator

➡ ***Please choose some prioritized actions from the list above and put them into the attached format "OJT Implementation Procedure".***

2. Please share the problems or issues you are facing with in your sites and organizations
3.Other Comments or Notes:

Output Challenge 1: Wiring Diagram of Pump Control Panel

Name of Participant: **Date:**

Name of Organization:

1. Please draw the general wiring diagram of the pump control panel.
2. Please add anything you learnt through this training.

Output Challenge 2: General Flow Diagram of Diesel Generator

Name of Participant: _____ **Date:** _____

Name of Organization: _____

1. Please draw the general flow diagram of the diesel generator.
2. Please add anything you learnt through this training.

WASA: _____ *Division:* _____ *Sub Division:* _____

Approved by: _____

Prepared by: _____

OJT Implementation Plan for Record Keeping, SOP & Device Inspection Activity of Electrical Panel

Administrative Information						Contents of Activity	Planning Date	Completed	Planning Date	Completed
Site No.	Site Name	Name of the Persons in Charge								
		XEN	SDO	Sub Engineer	Operator					
1.						Daily Operation Record				
						SOP Check List				
						Device Inspection Sheet				
2.						Daily Operation Record				
						SOP Check List				
						Device Inspection Sheet				

-Remarks-

OJT Implementation Procedure for O&M Manual, Record Keeping and Preventive Maintenance Activity of Diesel Generator

Administrative Information						Contents of Activity	Planning Date	Completed	Planning Date	Completed
Site No.	Site Name	Name of the Persons in Charge								
		XEN	SDO	Sub Engineer	Operator					
1.						1. O&M Manual				
						2. Basic Specifications				
						3. Daily O&M Record				
						4. Preventive Maintenance Plan				

-Remarks-