Annex 3.34
Training Material for O&M of Electrical Equipment
in Spring 2017

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 Akira Hasebe (Electrical)	
Course Leader Mubasher Ahmad Cheema	
Instructor Jawad Shahid	
Instructor Ihsan-ul-haque Javed	
Young Professional Tanveer Shahzad	

Course Dates

Modules	Dates	Themes
Module 1	April 10th to April 12th 2017	Electrical Control Panels
Module 2	April 13th to April 14th 2017	Generators & 5S
	April 15th 2017	Action Plan

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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?

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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?

Agenda

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

Agenda

- ✓ Introduction to Motor
- ✓ Power factor correction
- ✓ Record Keeping
- ✓ Standard Operation Procedure (SOP)
- ✓ Device Testing
- ✓ Preventive Maintenance

Class Evaluation Structure

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

Lecture Goals

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

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Electrical Control Panel

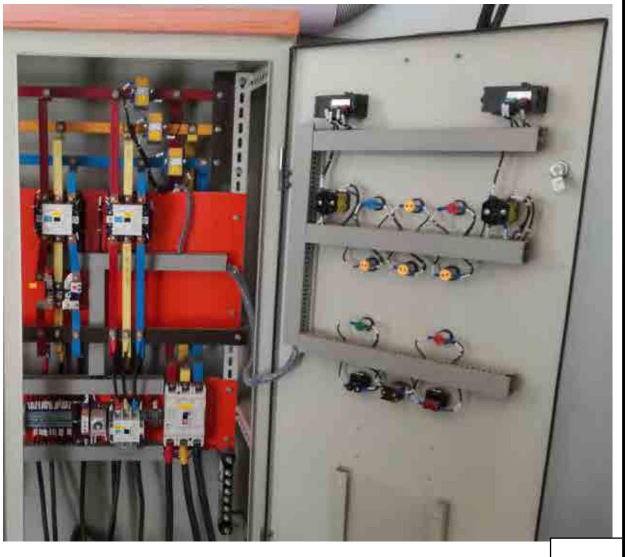
10/22

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?

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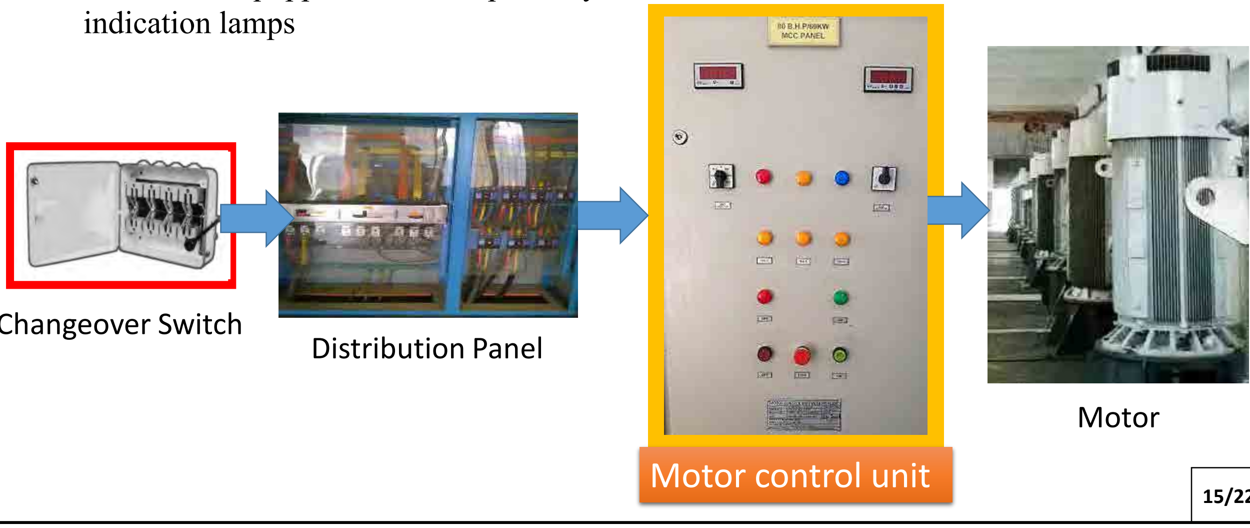
1.Motor control unit (MCU)

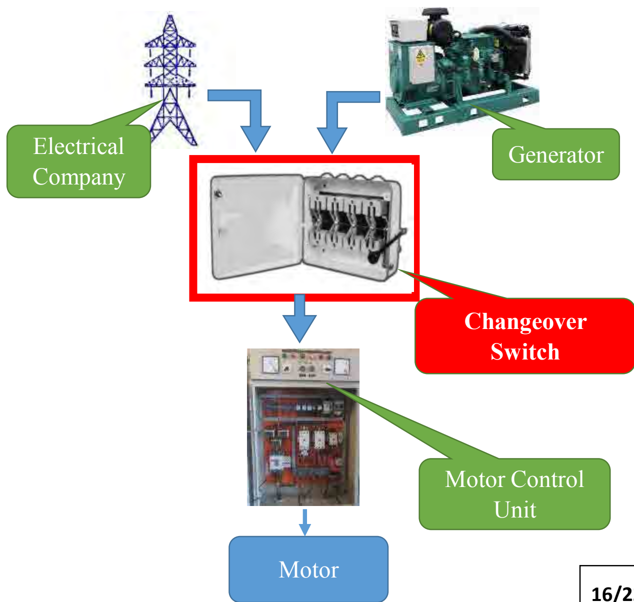
Motor Control Unit or simply MCU, are used to control and protect the electric motor. It is equipped with multiple relays, contactors, connections and indication lamps



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



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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.

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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

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Module 2: Electrical Panel and Instrumentation Equipment

Duration 3 days

Lecture + Exercise
Day 1

Briefings and On-The-Job-Training (2Days)
WASA Green Town Tubewell, Lahore

Day 1
- ✓ 3 hours for lecture
- ✓ 2 hours for exercises
- ✓ 1 hours for equipment demonstration

Day 2
- ✓ 2 hours for lecture
- ✓ 4 hours for OJT

Day 3
- ✓ Action Plan Briefing
- ✓ Maintenance plan exercise
- ✓ Prep. of action plan
- ✓ Group presentation of action plan
- ✓ Module wrap-up & Evaluation

20/22

Module 3: Generators

Duration 3 days

Lecture + Exercise
Day 1

Briefings and On-The-Job-Training (2Days)
Al-Jazari Academy, Lahore

Day 1
- ✓ 3 hours for lecture
- ✓ 2 hours for exercises
- ✓ 1 hours for equipment demonstration

Day 2
- ✓ 2 hours for lecture
- ✓ 4 hours for OJT

Day 3
- ✓ Action Plan Briefing
- ✓ Maintenance plan exercise
- ✓ Prep. of action plan
- ✓ Group presentation of action plan
- ✓ Module wrap-up & Evaluation

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Module 3: Introduction to SCADA & Health and Safety Environment (HSE)

Duration 3 days

Lecture + Exercise
Day 1

Briefings and On-The-Job-Training (2Days)
Green Town Filtration Plant, Lahore

Day 1
- ✓ 4 hours for lecture
- ✓ 2 hours for case study (WASA Faisalabad) and exercise

Day 2
- ✓ 2 hours of exercise (based on Konya SCADA system)
- ✓ 4 hours for OJT (HSE and 5S)

Day 3
- ✓ Action Plan Briefing
- ✓ Prep. of action plan
- ✓ Group presentation
- ✓ Wrap-up and Evaluation

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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

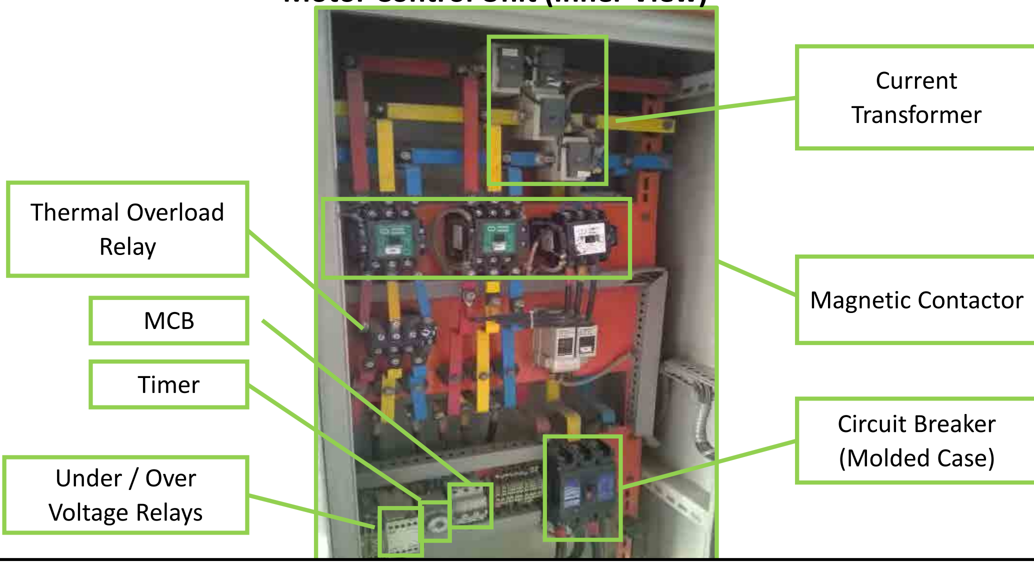
What are these?

Components of Electrical Control Panel

~ **Motor Control Unit (Outer View)** ~

Components of Electrical Control Panel

~ **Motor Control Unit (Inner View)** ~

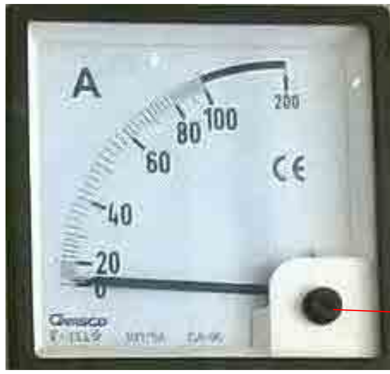


Selector Switches

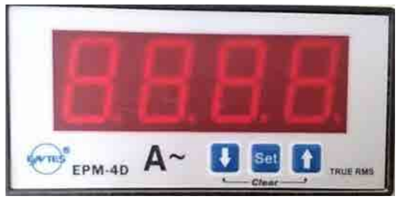
- ✓ Used to select among each of the three phases to monitor currents and voltages on ampere and voltmeter.

Ampere & Voltmeter meter

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



Zero Adjustment



1. Circuit Breakers

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

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.

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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

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6. Timer

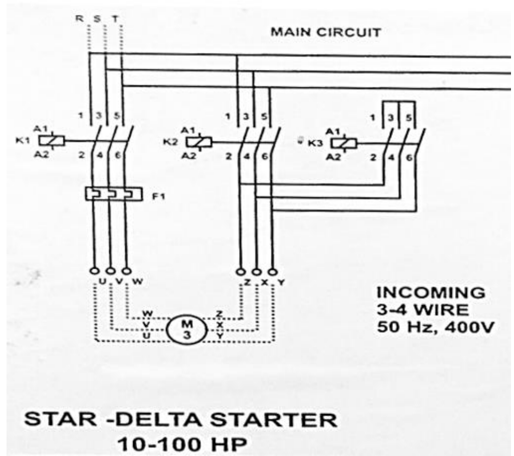
- ✓ Use to convert the motor connections from Star to Delta after specific time

WIRING DIAGRAMS

Wiring Diagram

✓ Shows how the components are connected

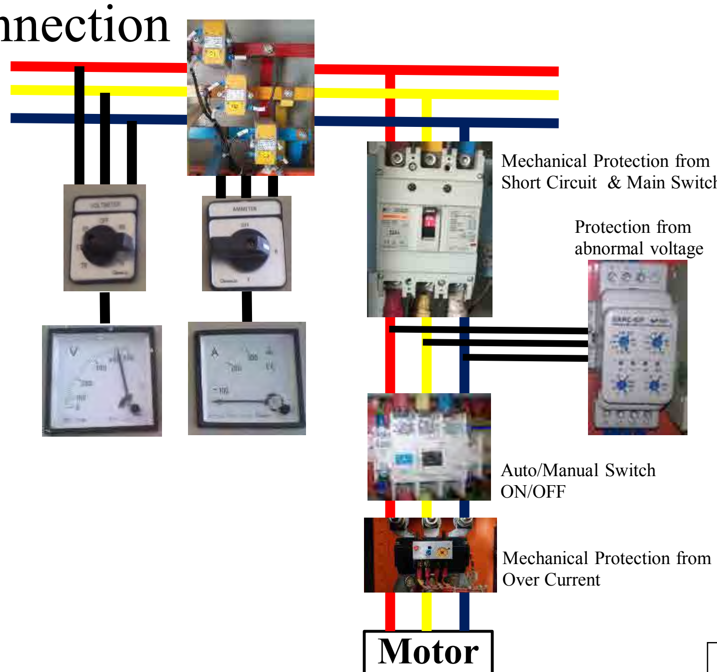
✓ It should be always available at the site



Basic Concept of Connection

WAPDA

3 phase, 400V



Basic Power Circuit for Motor in WASA

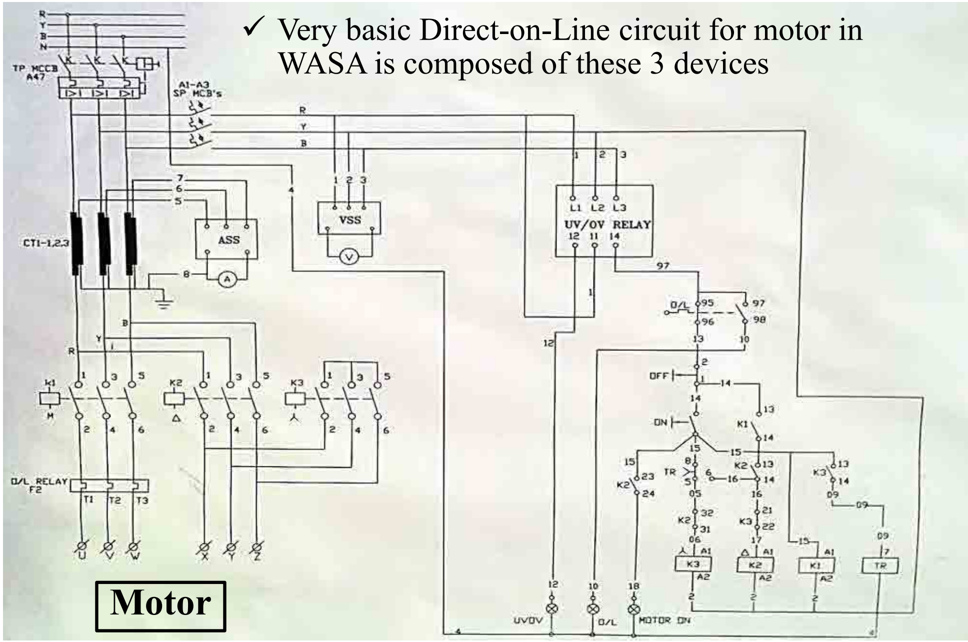
- Circuit Breaker
- Magnetic Contactor
- Over Load/Thermal Relay
- Over/Under Voltage Relay

Monitoring Device

- Voltage Meter
- Ampere Meter

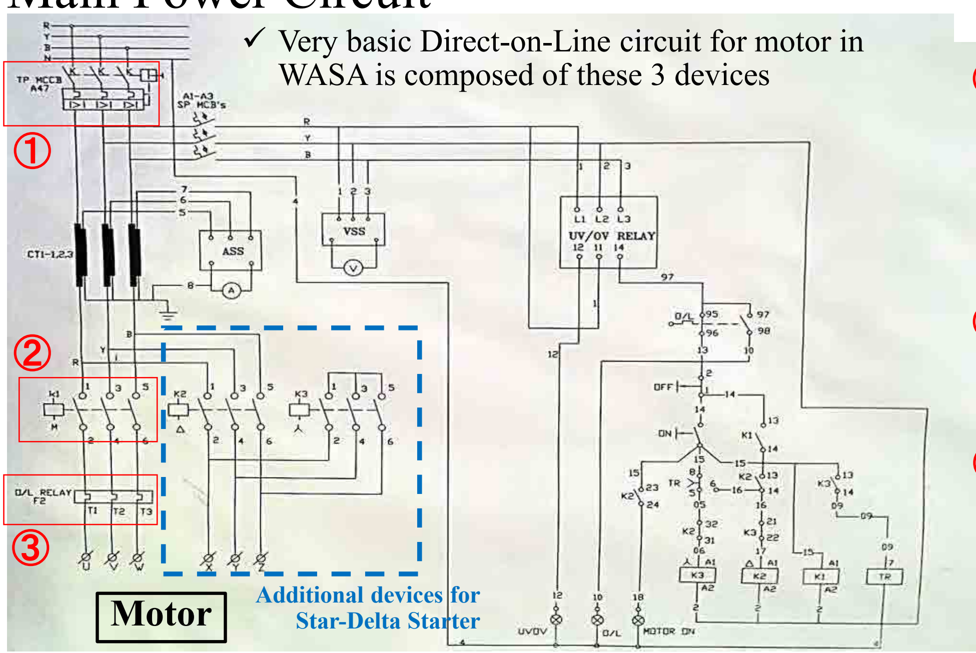
Main Power Circuit

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



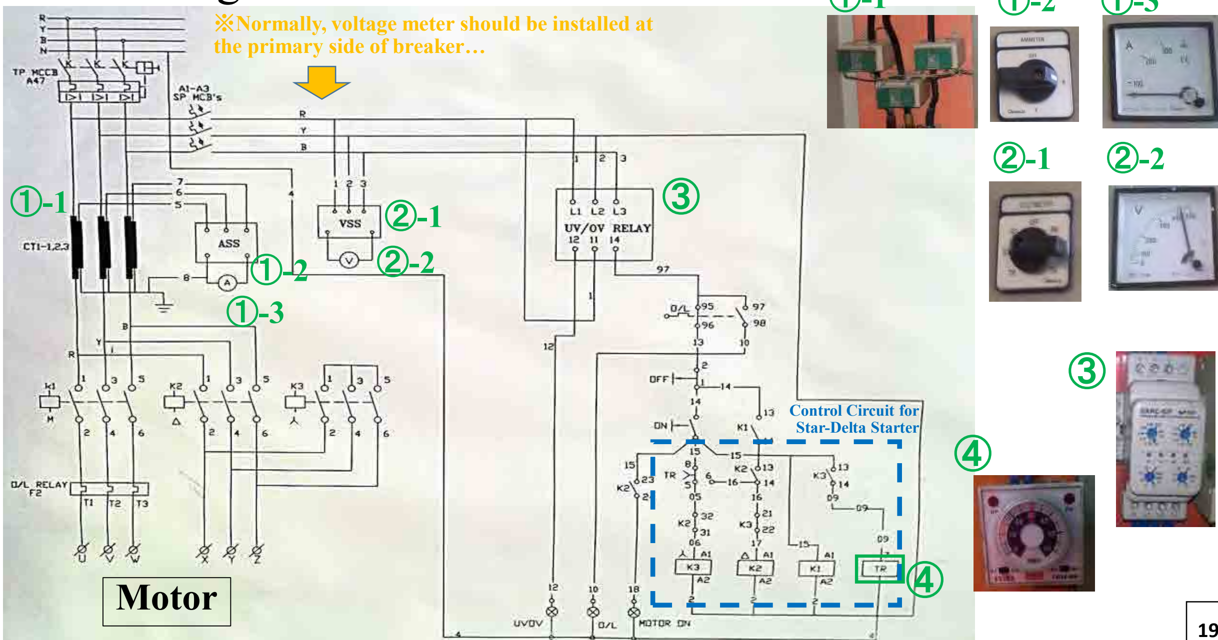
Main Power Circuit

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



Basic Power Circuit for Motor

Monitoring and Control Circuit



ACTIVITY – 1

Complete the wiring diagram with the suitable components

Motor, Motor Starters & Power Factor Improvement

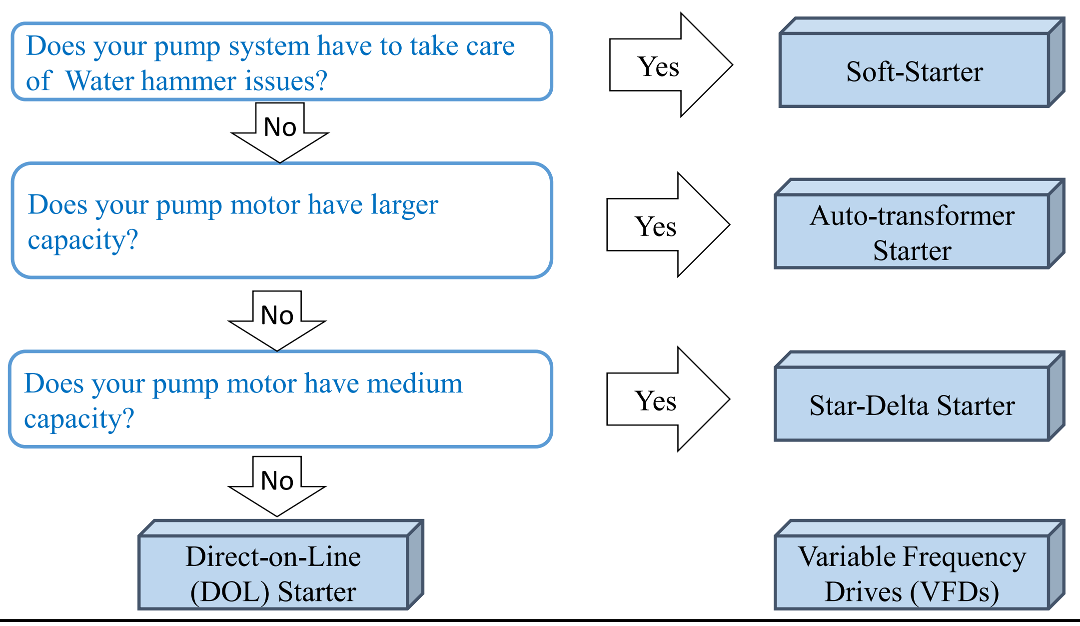
Goal of this Lecture

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

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.

Selection of Motor Starter

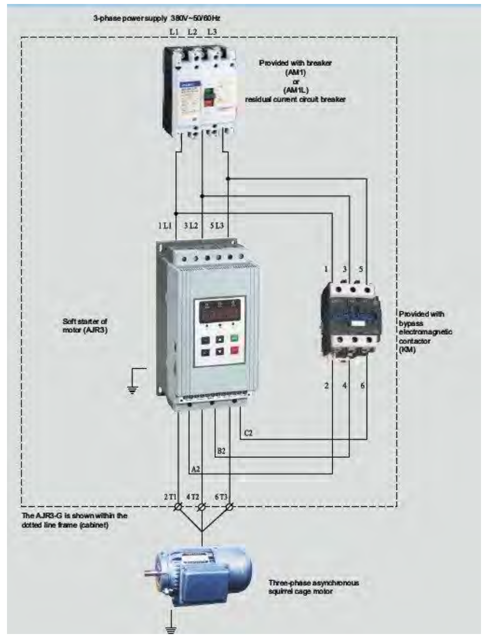


Soft Starter

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

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

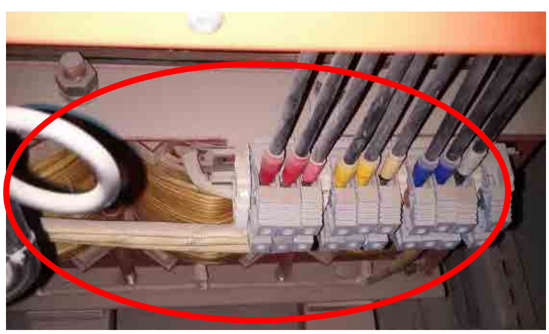
Disadvantage:
Electronic device shall be installed in a good environment so extra care is required



Single Line Diagram of Soft Starter

Auto-transformer Starter

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

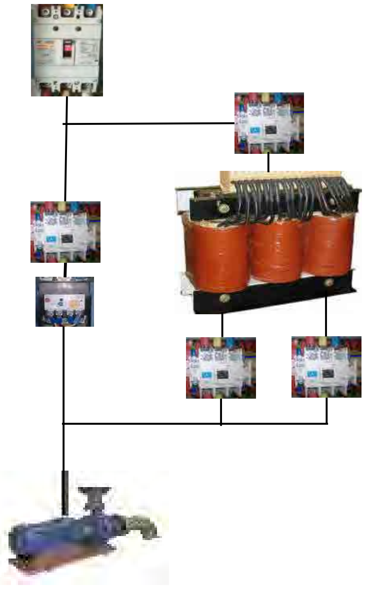


Transformer

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

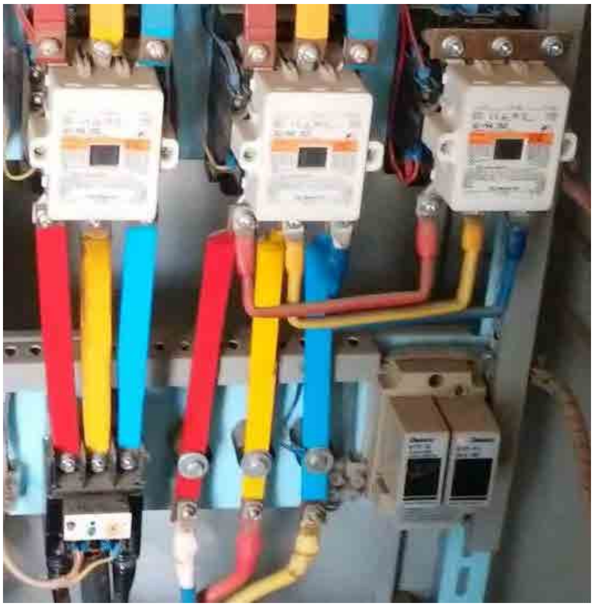


Single Line Diagram of Auto-transformer starter

Star-Delta Starter

Function:

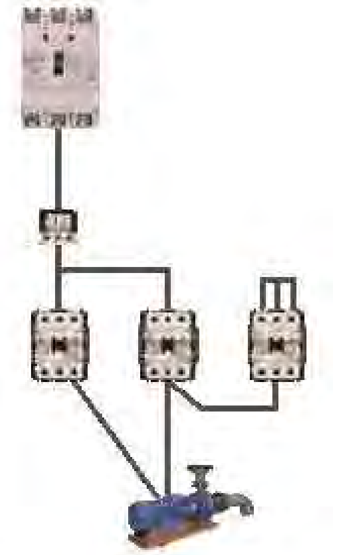
Arrangements of relays are so done that motor starts using star type connection and transferred to the delta type connection after few seconds



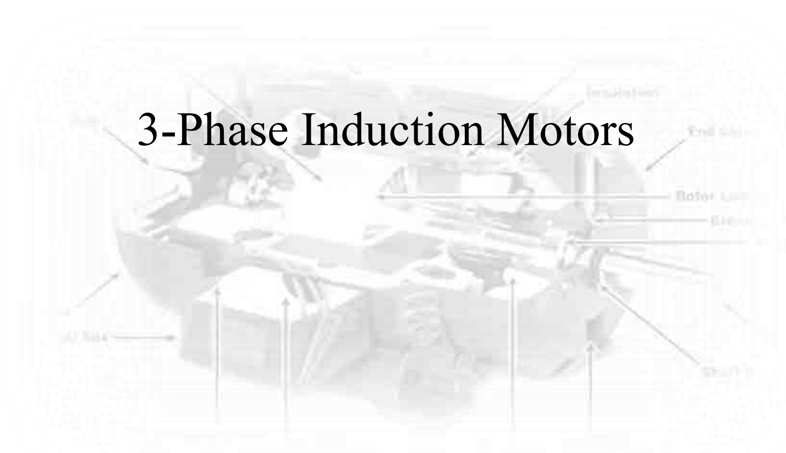
Star-Delta Starter

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



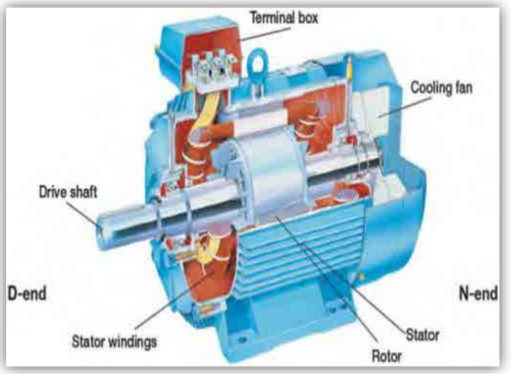
3-Phase Induction Motors

JICA

ALJAZARI ACADEMY

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.

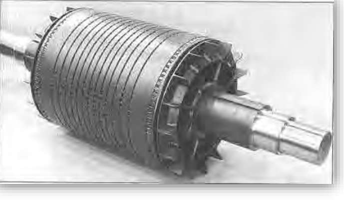


Basic Design and Construction

An induction motor has two main components:

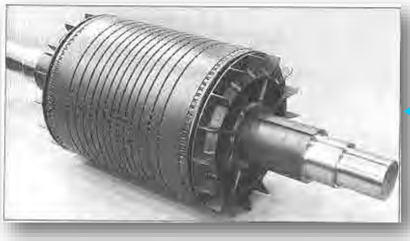
1. (Stationary part) Stator

2. (Revolving part) Rotor



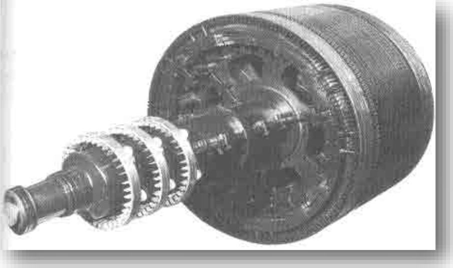
Basic Design and Construction

Rotor Types



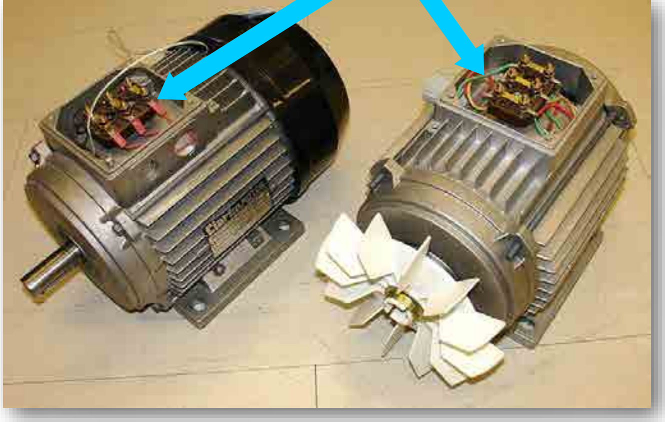
Squirrel cage rotor

Slip ring rotor



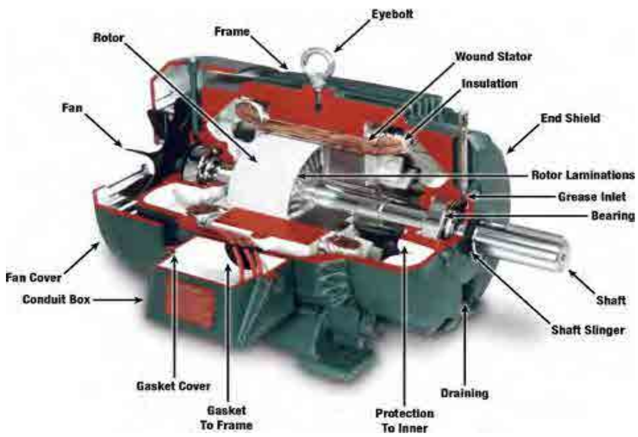
Basic Design and Construction

Terminals



Basic Design and Construction

Section View



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Basic Design and Construction

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Motor Burnout and Rewinding

Causes…

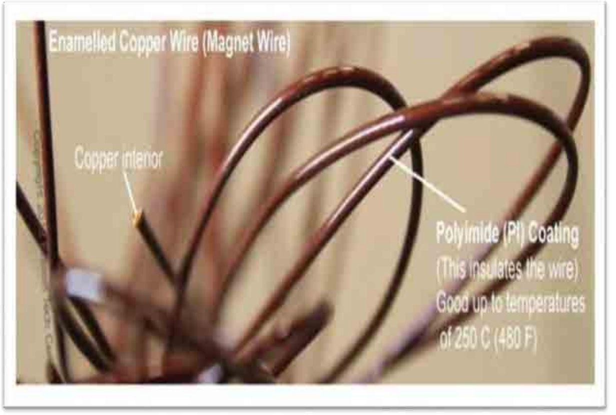
1. Fluctuation in phase voltages
2. Malfunctioning of protective relays
3. Manufacturing defects
4. Damage before or during installation
5. Improper installation
6. Misapplication (overload)

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)

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.



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

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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 !!!

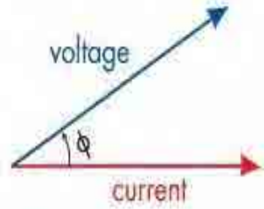
POWER FACTOR IMPROVEMENT

Power Factor Improvement

What is Power Factor?

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

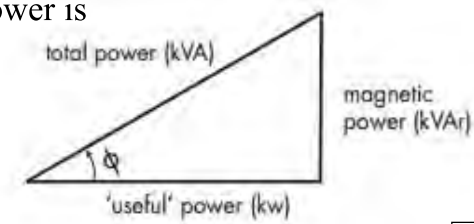
Power factor (pf) = (Useful Power kW)/(Total power kVA) kW= kVI cosø



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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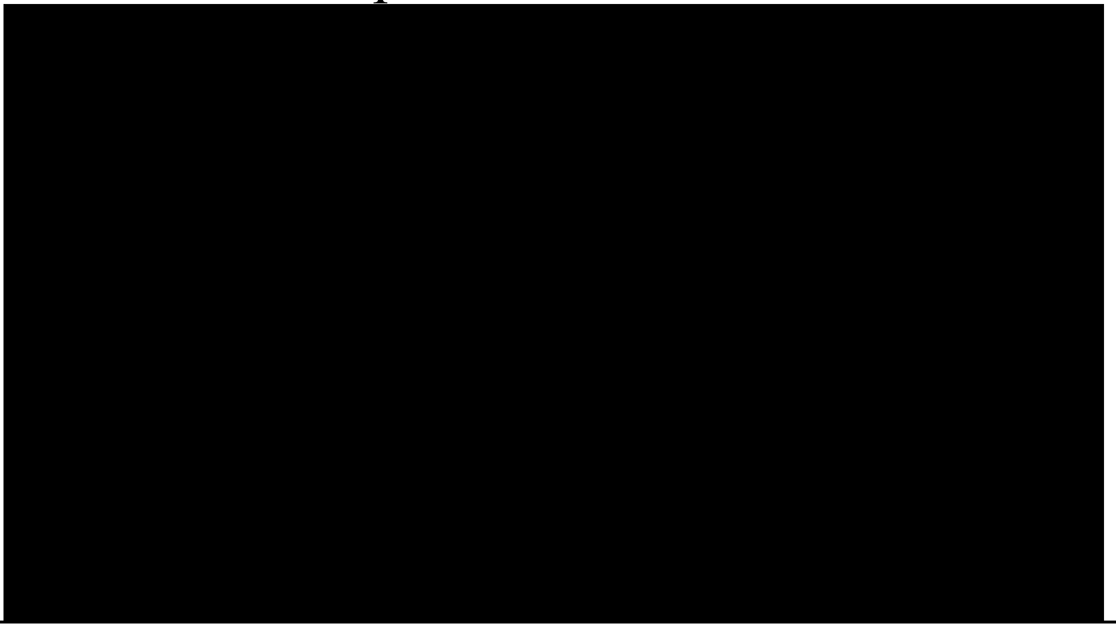
Power Factor Explained



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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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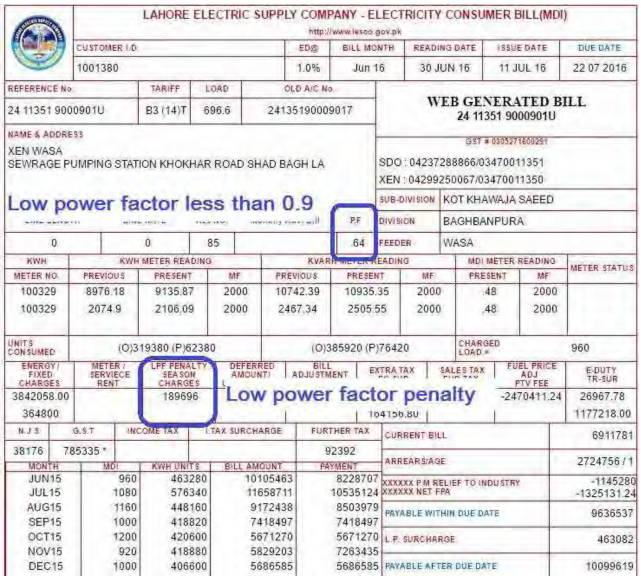
Auto Power Factor Controller

- ✓ 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

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

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

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

GST # 0305271600291
SDO : 04237288866/03470011351
XEN : 04299250067/03470011350

Low power factor less than 0.9

				P.F
0	0	85		.64

SUB-DIVISION	KOT KHAWAJA SAEED
DIVISION	BAGHBANPURA
FEEDER	WASA

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 / SERVIECE 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					-2470411.24	26967.78
364800					164156.80			1177218.00

Low power factor penalty

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

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

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

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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.

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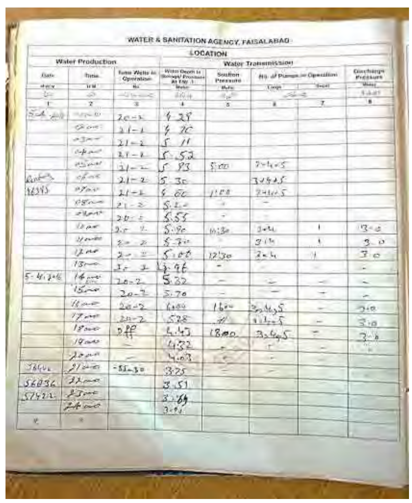
RECORD KEEPING

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



How to make daily operation record

Factors to note down during record keeping (Pumps):

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

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STANDARD OPERATING PROCEDURE (SOP)

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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

△ : 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																	

Check List for Standard Operation Procedure

Check List of Standard Operation Procedure for Electrical Facility

Approved by : SDO

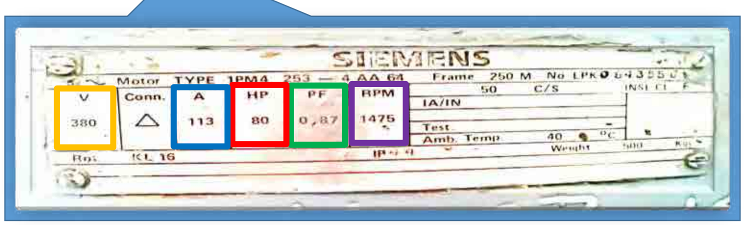
Inspected by : Sub Engineer (Electrical)

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



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

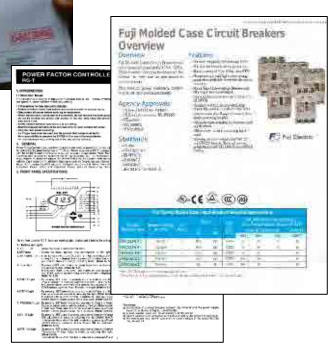
✓ : Good ✕ : No care at all or need to be newly installed

△ : 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																	

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

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
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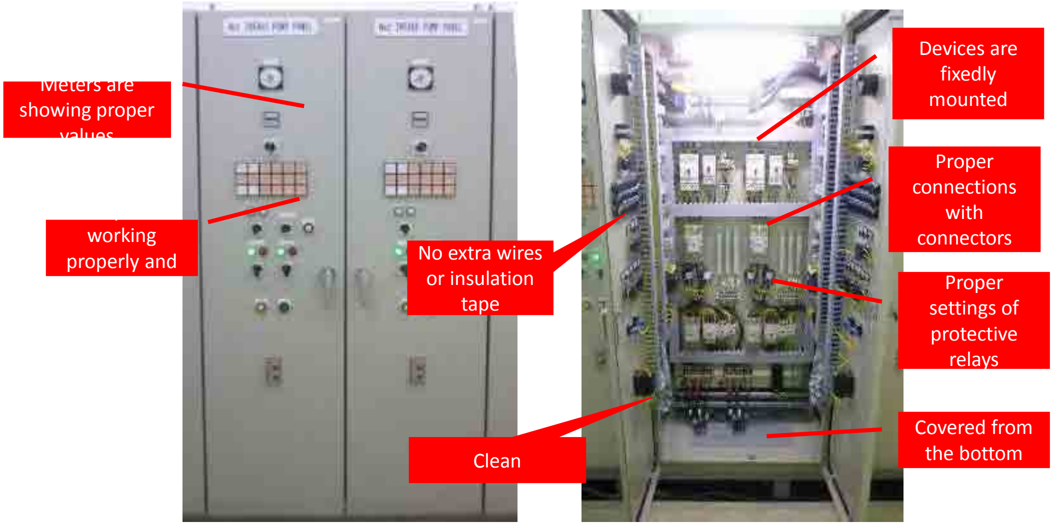
1																	
2																	
3																	

Comparison of the Panel Conditions

NEED TO BE IMPROVED

Comparison of the Panel Conditions

IDEAL CONDITION OF A PANEL



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

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

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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																	

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

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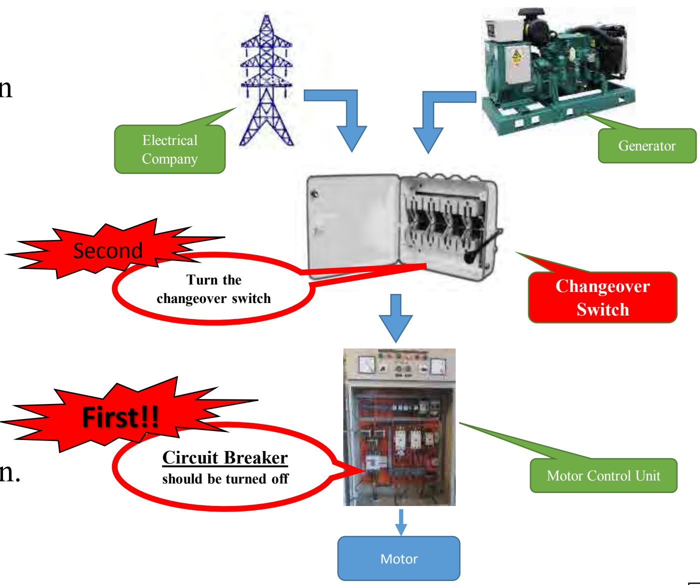
- How to operate changeover switch -

- ✓ 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.

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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

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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.

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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

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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 -						

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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

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Appendix

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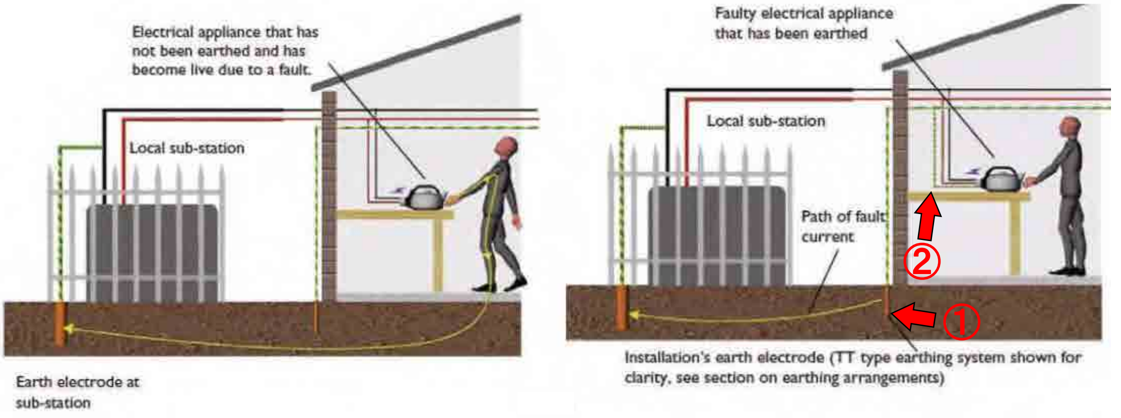
Electrical Leakage

- 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

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

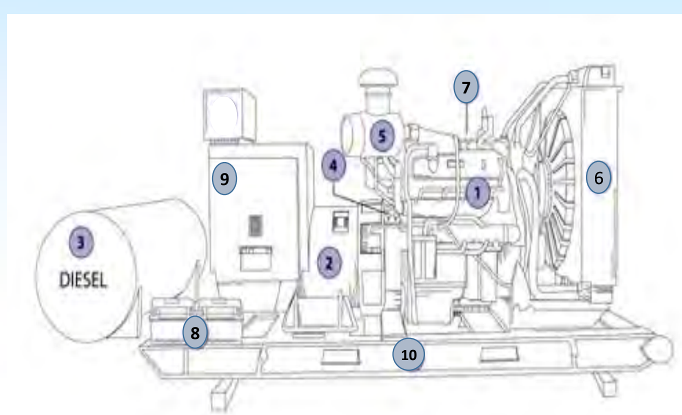
4. Rotor of alternator starts to rotate

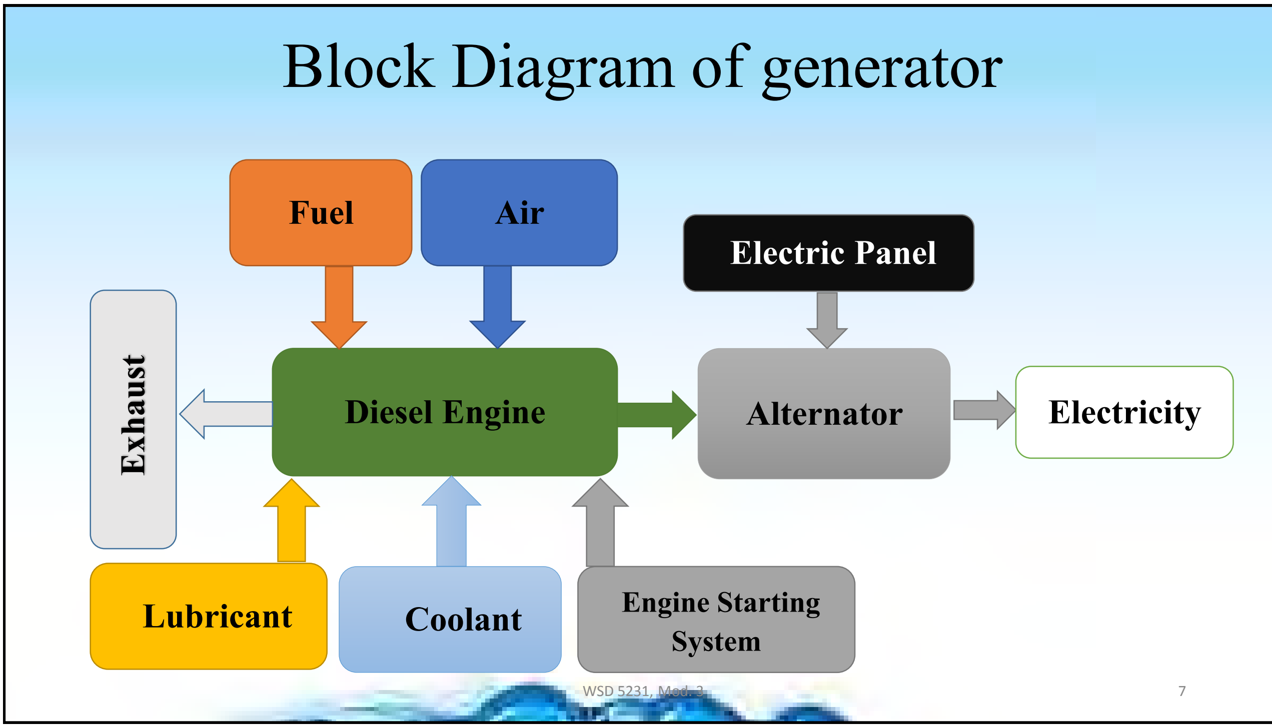
5. Stator of alternator generates power

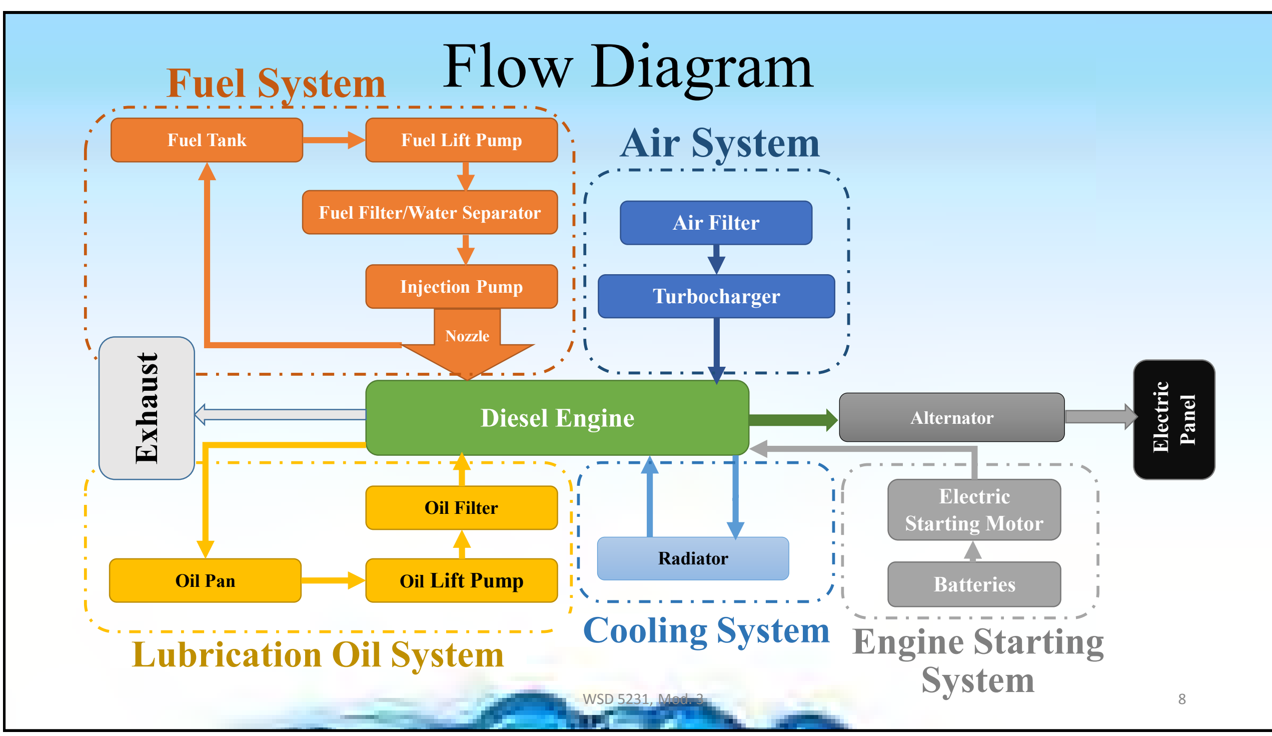
Basic design of generator

✓ 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
Fuel
Air
Electric Panel
Exhaust
Diesel Engine
Alternator
Electricity
Lubricant
Coolant
Engine Starting System
WSD 5231, Mod. 2
7


Flow Diagram
Fuel System
Fuel Tank
Fuel Lift Pump
Fuel Filter/Water Separator
Injection Pump
Nozzle
Air System
Air Filter
Turbocharger
Exhaust
Diesel Engine
Alternator
Electric Panel
Oil Filter
Oil Pan
Oil Lift Pump
Lubrication Oil System
Radiator
Cooling System
Electric Starting Motor
Batteries
Engine Starting System
WSD 5231, Mod. 2
8

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

WSD 5231, Mod. 2 9

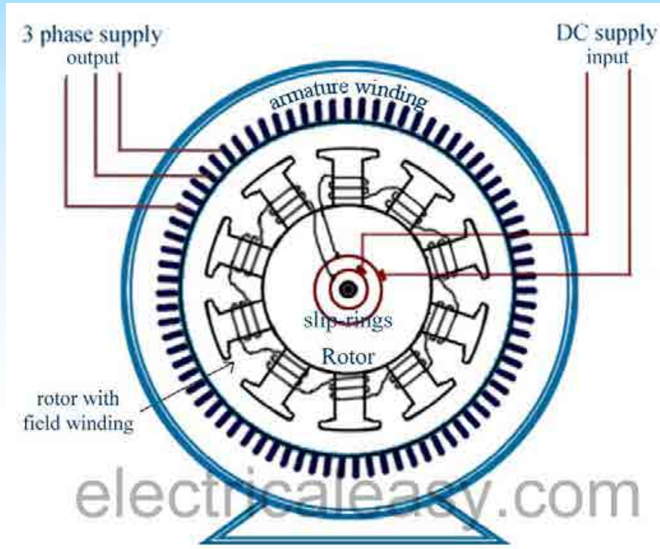
2. Alternator

- ✓ 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

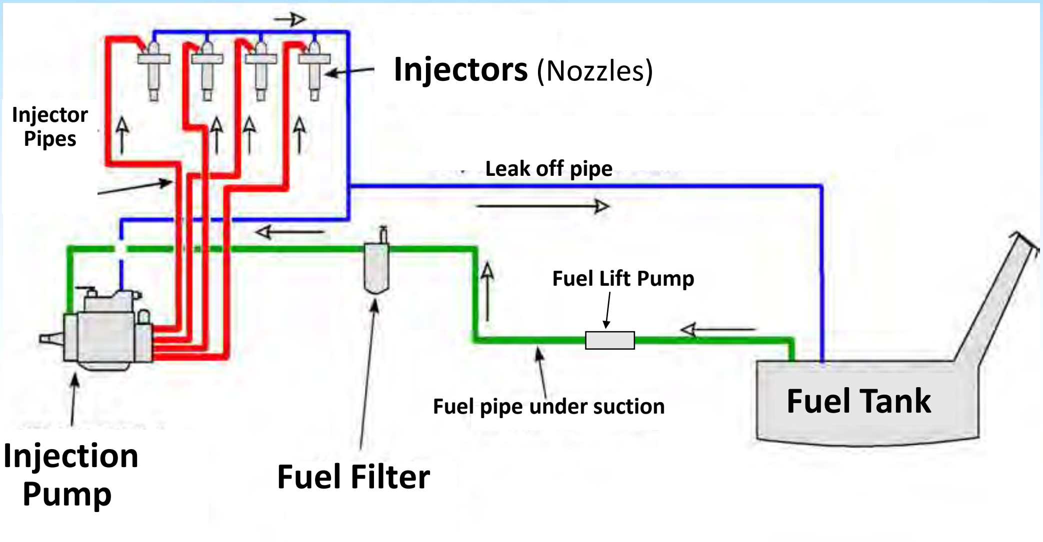
WSD 5231, Mod. 2 10

2. Alternator

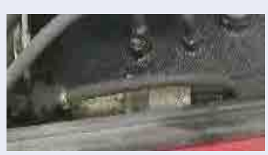


2. Alternator

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

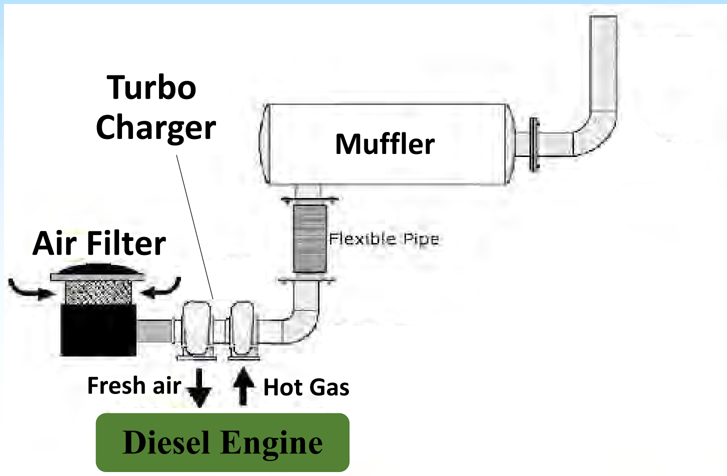
Components of Fuel System

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

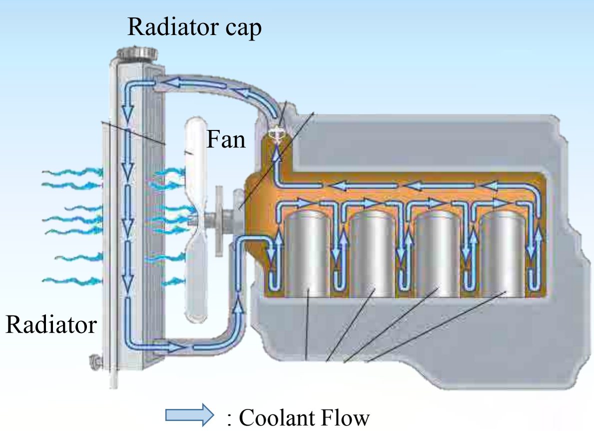
Function:

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.

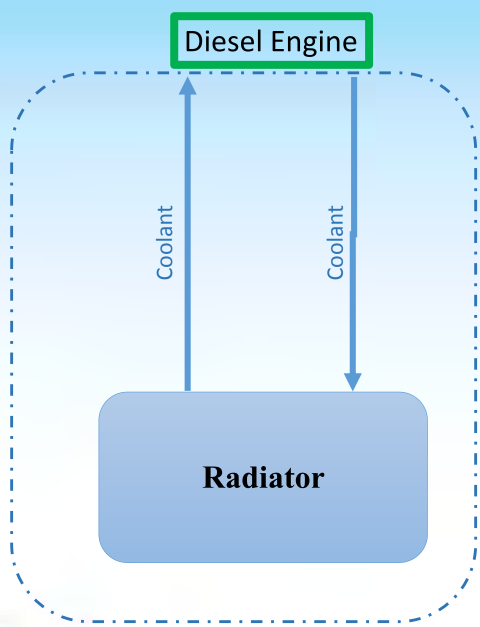
Components:

1. Radiator/ Charge air cooler
2. Thermostat

6. Cooling System



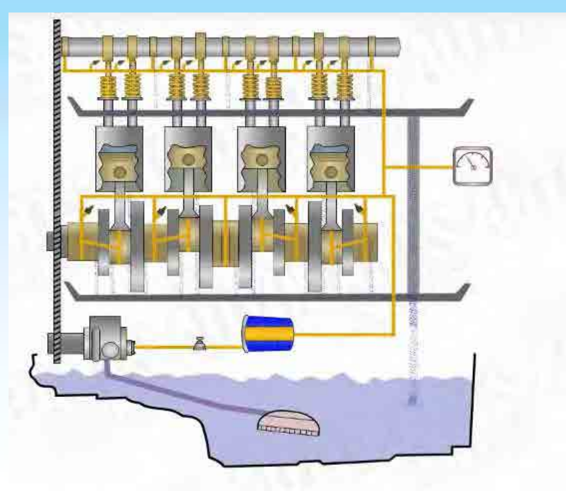
Cooling System



Components of Cooling System

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

7. Lubricating System


Lubrication system

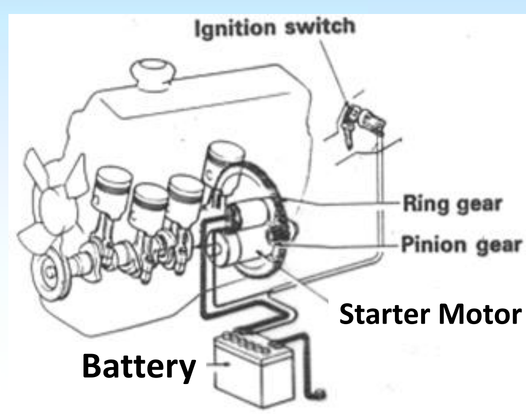
- ✓ Generator comprises moving parts in it's engine, So lubrication is required for long lasting operation.
- ✓ The generator's engine is lubricated by oil stored in an oil pan.

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

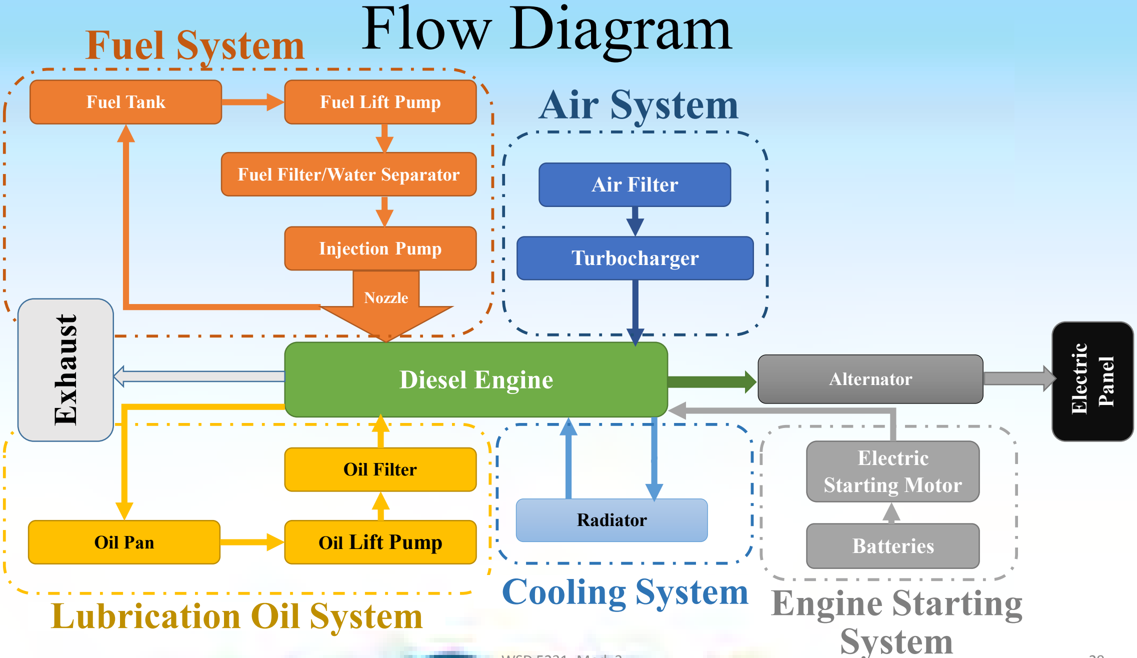
Alternator (Main)	**Electrical Panel**	**Cables**
		
Provide main alternative power supply	**Monitor and control the system through sensors and provide electrical energy with protection**	**Provide electrical connectivity between the alternator and other electrical component**

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

<u>Following steps are required to calculate required size of the generator:</u>

<u>Step 1:</u> Calculate the power of all non-motor loads

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

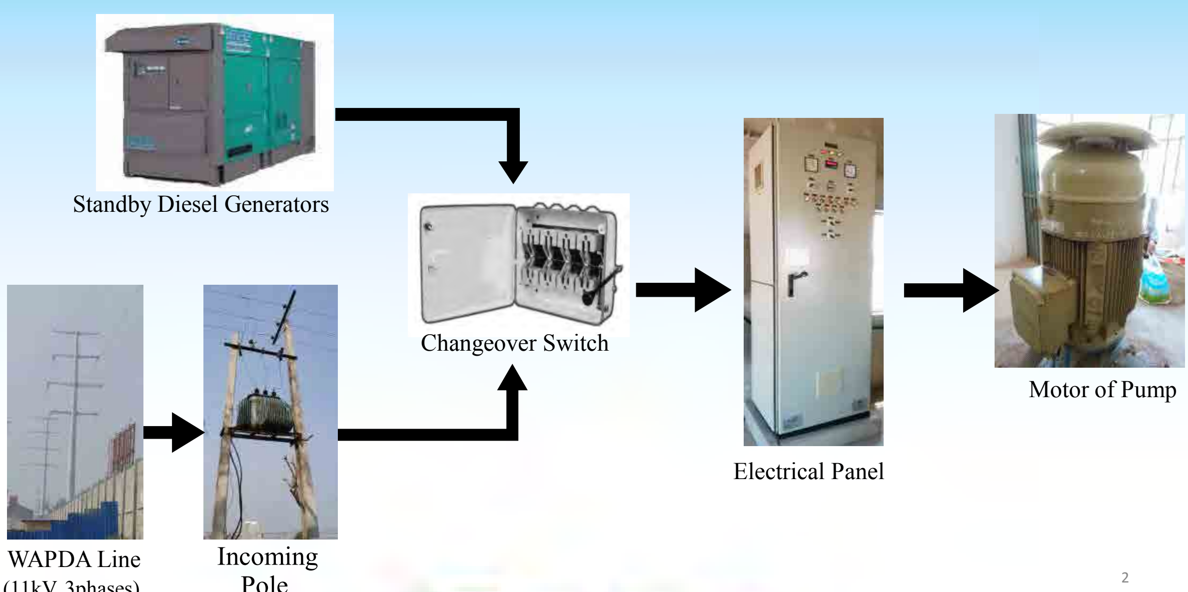
<u>Step 3:</u> Add all motor's running load and starting load of the largest motor

<u>Step 4:</u> Add non motor loads into the value of step 3

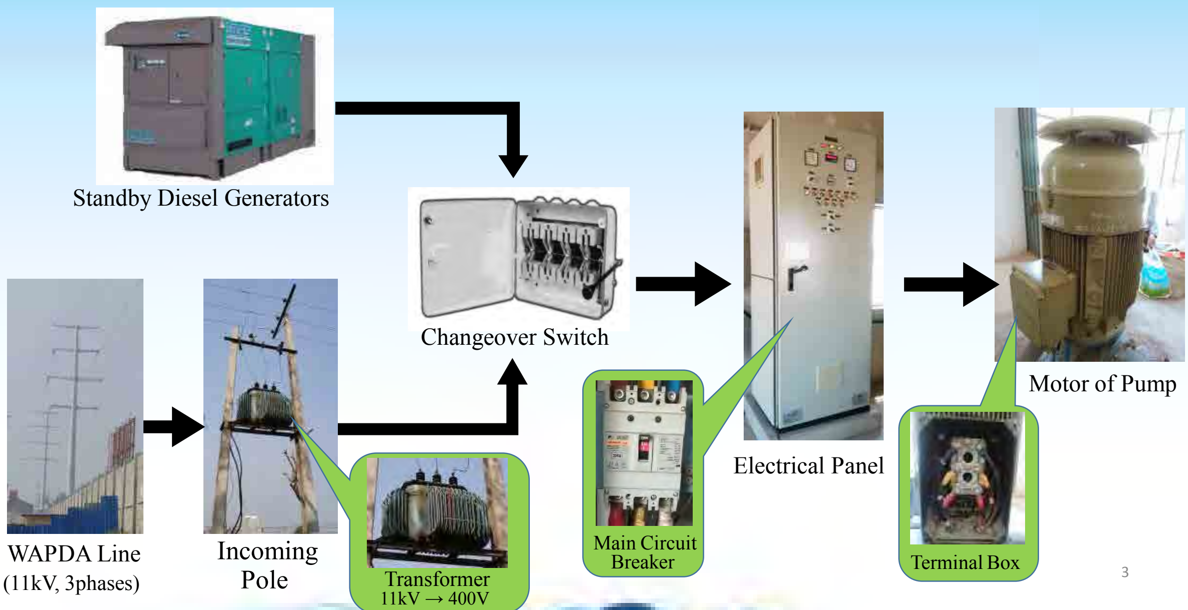
<u>Step 5:</u> Select Generator's rating of at least 125% of the final answer of step 4

Standard Operation Procedure for Generator

Electrical Connection's Overview

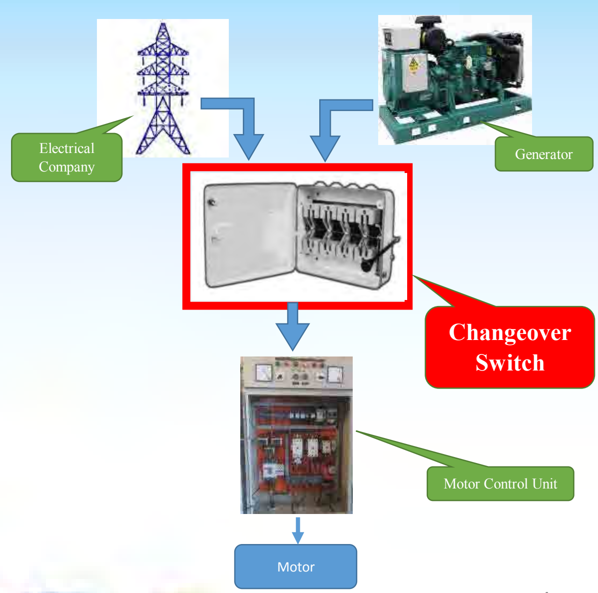


Electrical Connection's Overview



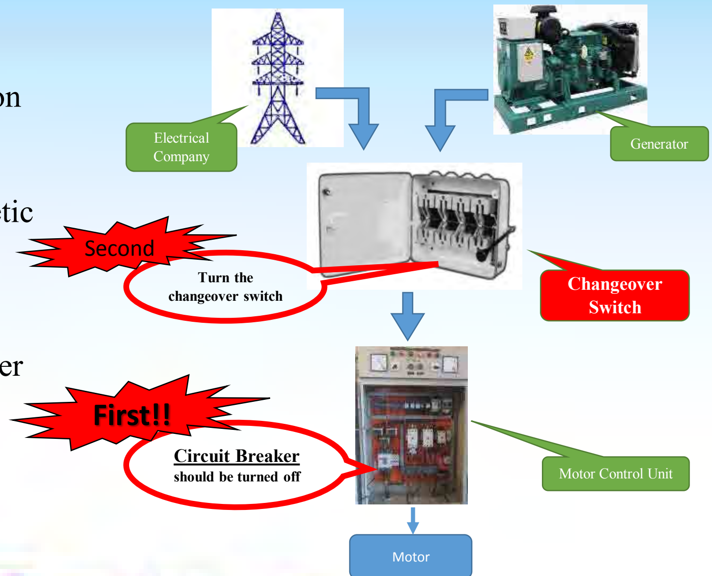
Changeover Switch Operation

✓ 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



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

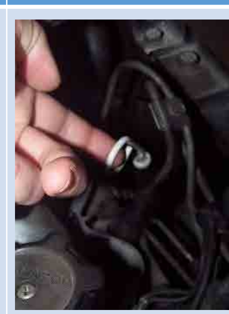
- **Turn off the following devices first:**
- **Main circuit breaker of Electrical Company's line**
- **Circuit breaker of Motor control unit**
- **Circuit breaker of the generator**
- **<u>Rotate changeover switch to generator</u>**

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

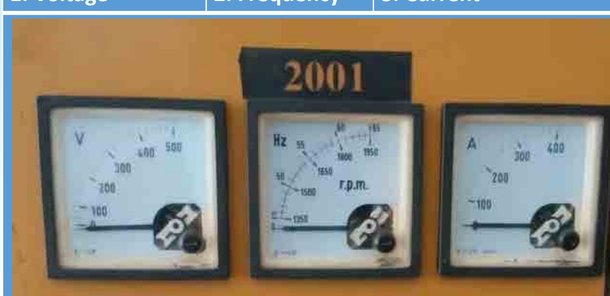
Parameters To Be Cared For Before Operation

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

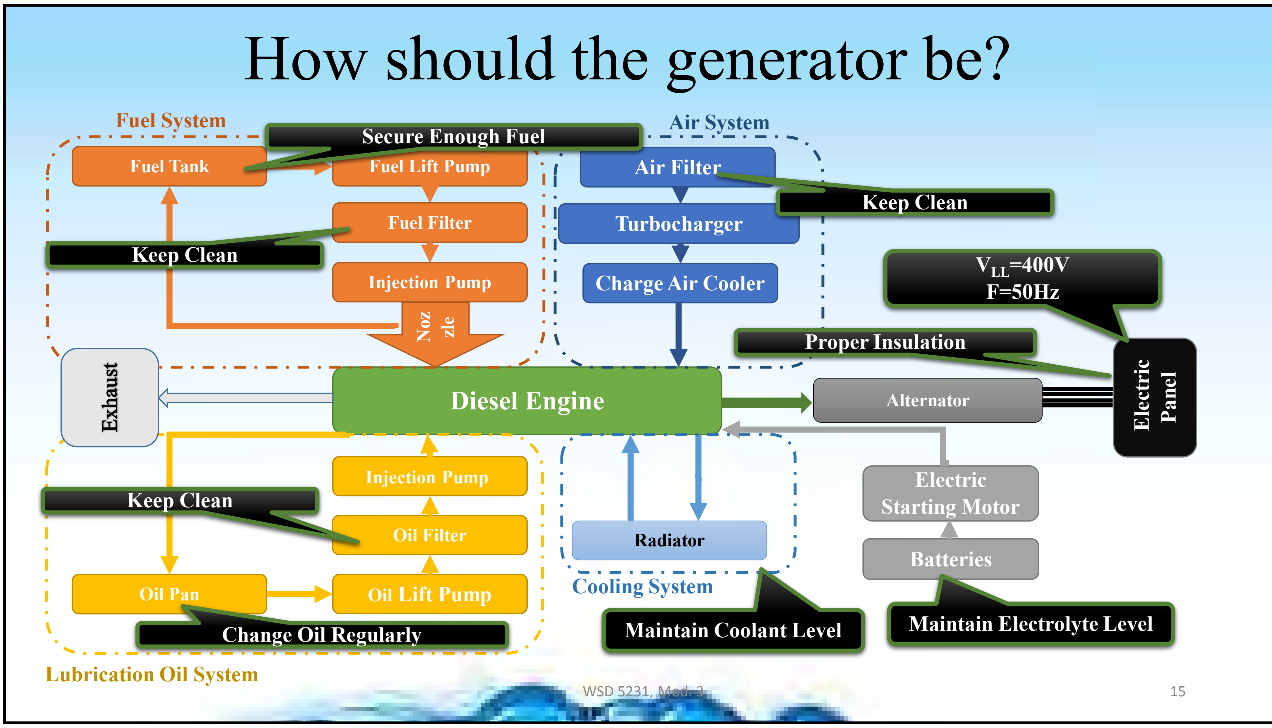
c. Unusual engine noise

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?
Fuel System
Secure Enough Fuel
Air System
Fuel Tank
Fuel Lift Pump
Air Filter
Keep Clean
Fuel Filter
Turbocharger
Keep Clean
Injection Pump
Charge Air Cooler
V_{LL}=400V
F=50Hz
Nozzle
Proper Insulation
Exhaust
Diesel Engine
Alternator
Electric Panel
Injection Pump
Keep Clean
Electric Starting Motor
Oil Filter
Radiator
Batteries
Oil Pan
Oil Lift Pump
Cooling System
Change Oil Regularly
Maintain Coolant Level
Maintain Electrolyte Level
Lubrication Oil System
WSD 5231, Mod. 3
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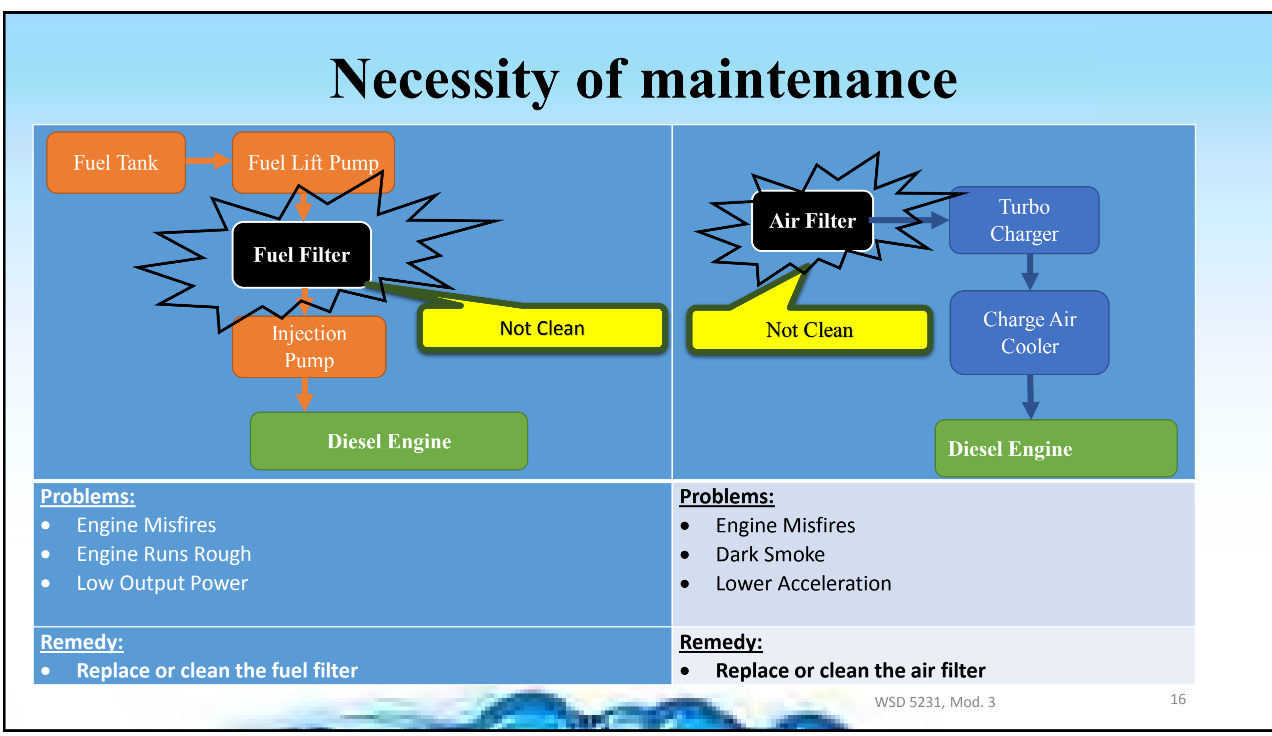
Necessity of maintenance
Fuel Tank
Fuel Lift Pump
Fuel Filter
Injection Pump
Not Clean
Diesel Engine
Air Filter
Turbo Charger
Not Clean
Charge Air Cooler
Diesel Engine
Problems:
Engine Misfires
Engine Runs Rough
Low Output Power
Problems:
Engine Misfires
Dark Smoke
Lower Acceleration
Remedy:
Replace or clean the fuel filter
Remedy:
Replace or clean the air filter
WSD 5231, Mod. 3
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Daily and Periodic Maintenance Sheet

Sr. No.	Activities	Service Type: Daily	Weekly	Monthly	6 Months	Last Activity Date	Year____ Month____ 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				●						

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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					

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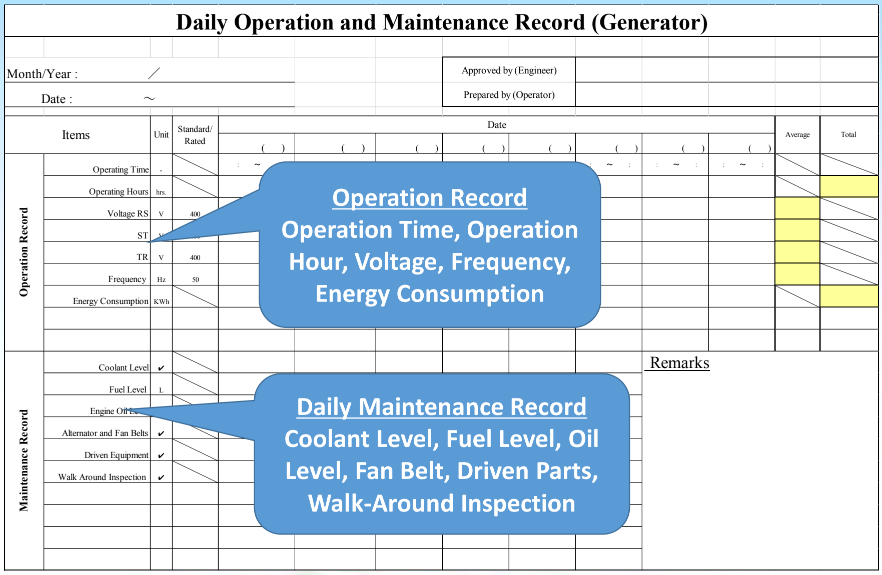
Daily Operation & Maintenance Record


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	✔											

Daily Maintenance Checks

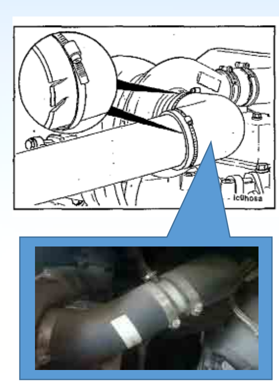
- ***Electric panel***

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

<u>Walk-around inspection</u>

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.

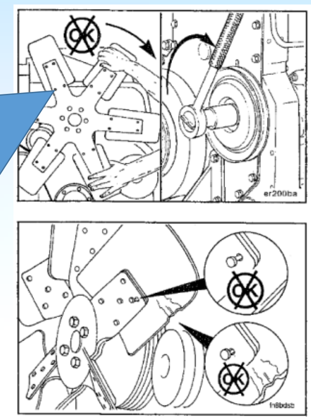
Replace damage piping and replace loose clamps.

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

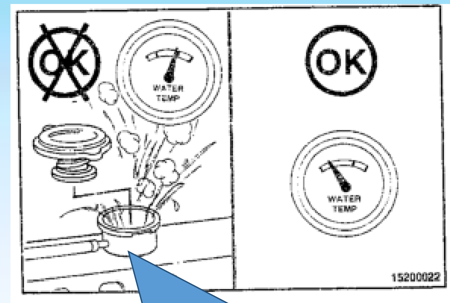
Visually inspection is required to check for cracks, loose rivets and bent or loose blades.

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

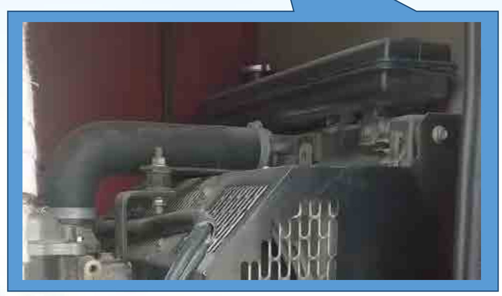
Daily Maintenance Checks



Engine coolant level

✓ Do not remove the pressure cap from the hot generator. Wait until the coolant temperature is below 50 °C before removing the pressure cap.

✓ To add coolant, the ratio of coolant and anti-freeze must be according to the recommended weather conditions.

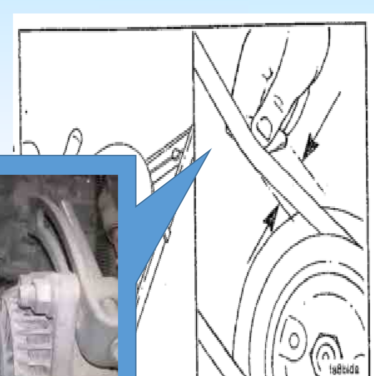


Daily Maintenance Checks

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.

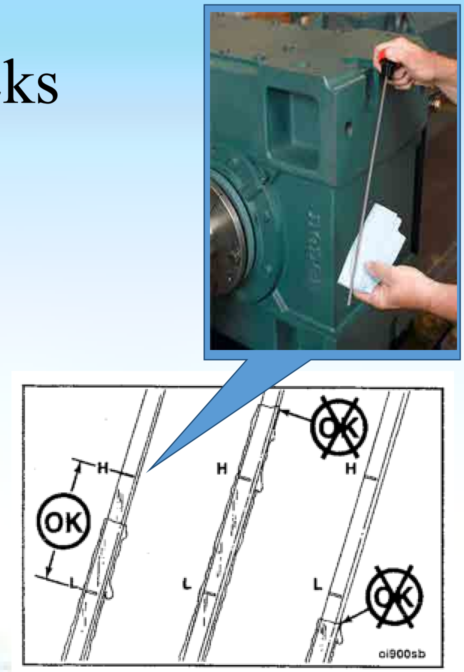
Fuel System

Daily Maintenance Checks

<u>Engine lubrication oil level</u>

- ✓ 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.



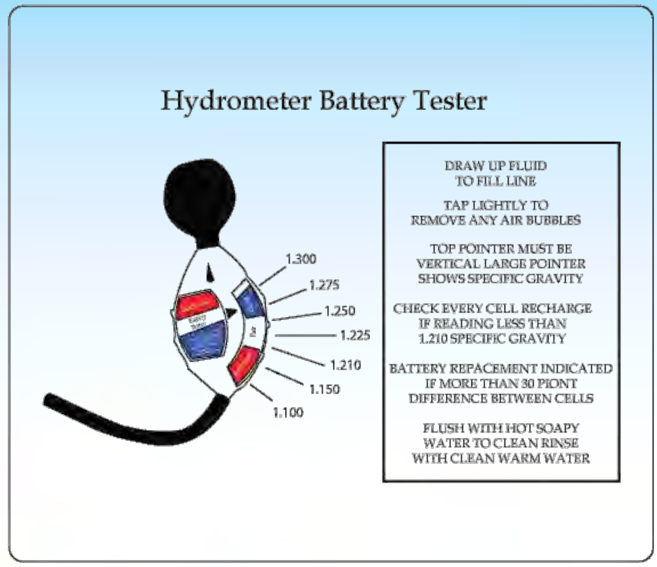
DC Electrical- Areas of concern

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.

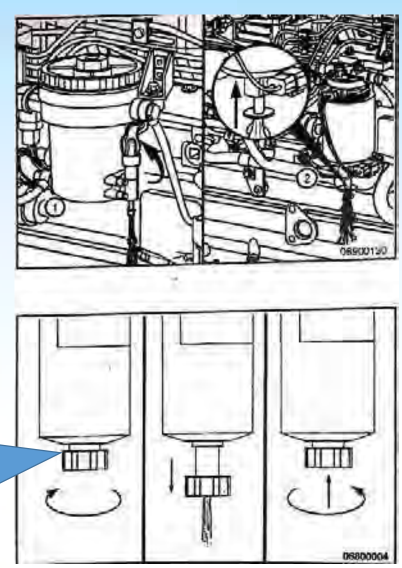


Daily Maintenance Checks

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.

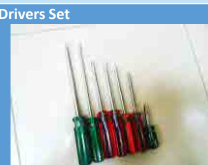
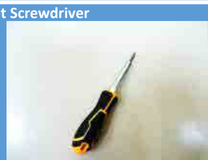


Engine Operation Report

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

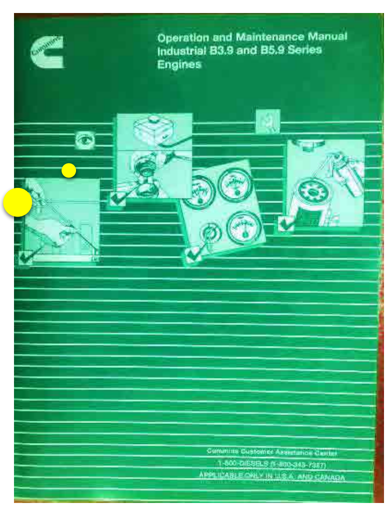
Necessary Tools

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

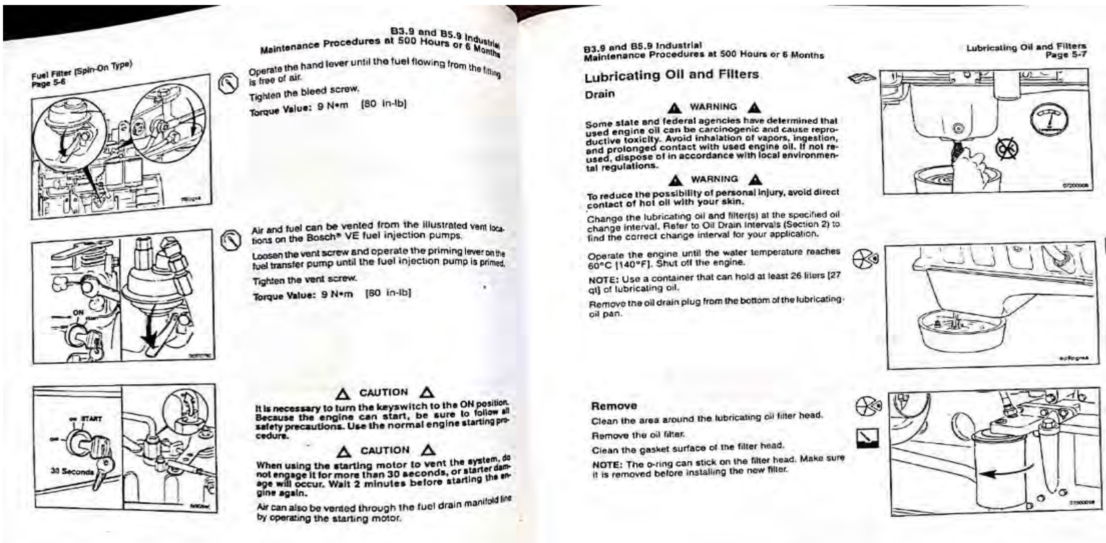
Introduction of manufacturer's O&M manual

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



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

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

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.

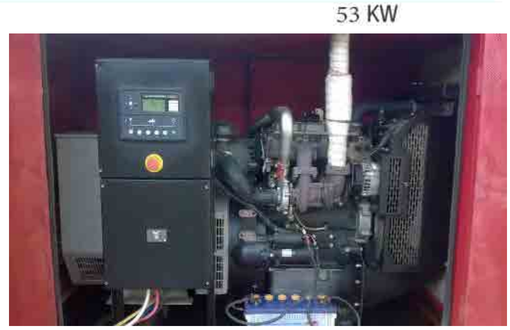
Clean the gasket surface of the filter head.

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

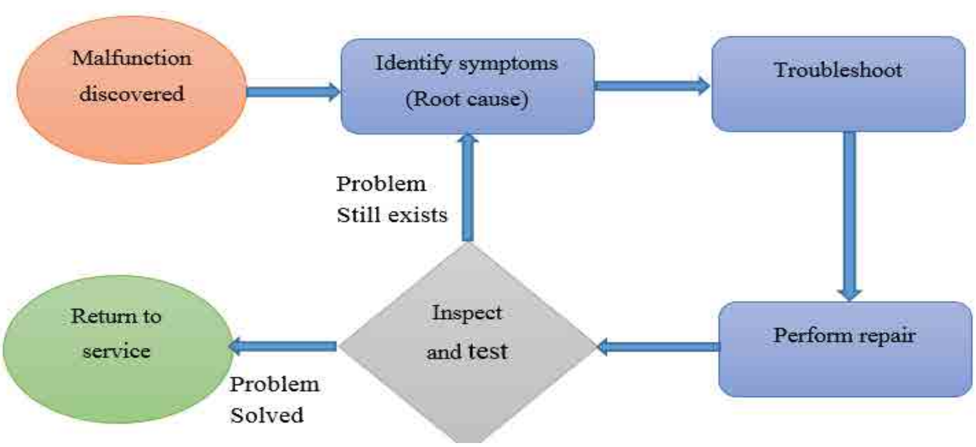
ENGINE / TECHNICAL DATA

Ratings at 0.8 Power Factor

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			
Frequency and Engine Speed	**50Hz & 1500rpm**		**60Hz & 1800rpm**	
	Prime	**Standby**	**Prime**	**Standby**
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

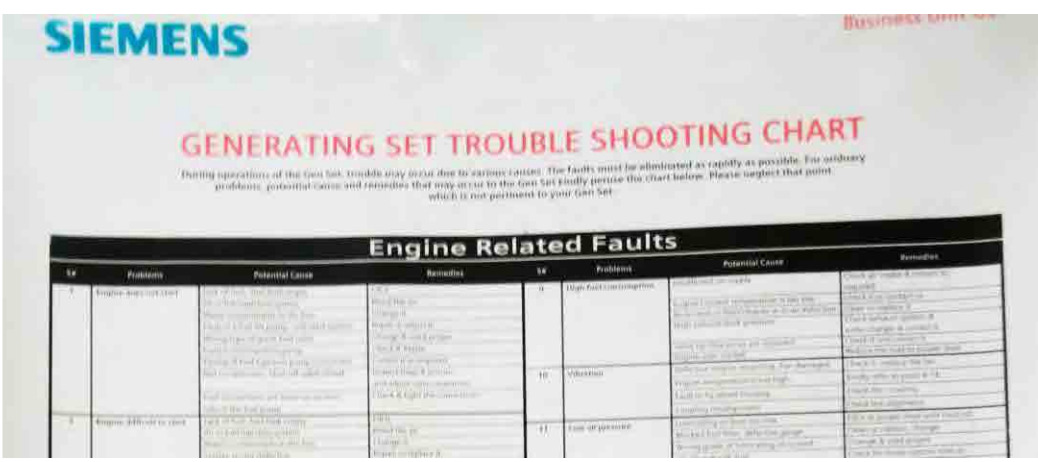
7.1 Troubleshooting system chart

Alternator not working

Causes	Correction
Alternator pulley loose	Tighten the pulley, refer to owner's manual
OK	
Batteries have malfunctioned	Check condition of batteries replace if necessary
OK	
Battery cable connections loose/broken	Check the battery cables and connections
OK	
Alternator is overloaded	Install an alternator with higher capacity, refer owner's manual
OK	
Alternator or AVR malfunctioning	Test the alternator output, replace alternator or AVR if necessary
OK	
Battery temperature above specification	Position the batteries away from heat source, refer manual
OK	
Electrical system open or blown fuse	Check the wire, fuses and connection. Refer to manual
OK	
Gauge is malfunctioning	Check the gauge, refer to owner's service manual
OK	
Contact authorize repair facility	

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 !!!

OJT

Operation and Maintenance of Electrical Equipment

Health Safety & Environment for Electrical Components

2

Activities for On-the-Job Training

1. Electrical Panel
2. Generator

- Hazard Hunting
- Job safety analysis (JSA)
- Introduction of PPE
- Firefighting
- Electric Shock Management
- Electrical Safety Rules
- First Aid Box & Record keeping
- Accident or Incident Reporting

3

Hazard Hunting

What is Hazard?

Hazard is a situation that poses a level of threat to Life, Health Property or Environment for example, Electric shock, Electric fire, poor illumination at Electrical panel room or Electrical spark due to loose electrical connections.

4

Hazard Hunting

Types of Hazard

Physical
- Installations
- Natural conditions
- Noise &vibrations

Mechanical
- Electricity
- Equipment
- Pressure vessels

Chemical
- Effluents
- Air emissions
- Toxic material

Biological
- Bacteria
- Virus
- Pathogens

Psychological
- Stress
- Ergonomics
- Exertions

5

Hazard Hunting

Hazard can be related to

Safety: Related to safe O&M

Health: Related to employee or public health

Environment: Related to environmental factors

Technology: Accident / incidents related to operations etc.

Behavior: Reaction of employee to working conditions

6

Hazard Hunting

Sources of Hazard Identification

- Employee
- Operations & maintenance
- Working conditions & Environment
- Equipment / installation manual
- Common sense
- Accident / incident record

Hazard Hunting

Hazard hunting is a 4-step procedure.

- **S** Spot the Hazard
- **A** Assess the Hazard
- **F** Fix the Problem
- **E** Evaluate the Hazard

Hazard Hunting

Regular inspections for operation and maintenance jobs and identification of related hazards are identified by the facility staff and reported to facility supervisor or in charge. After collection of data, facility in-charge should fill up the identified hazard in a template as a record

Sr. #	Potential Hazard (Spot)	Action needed (Assess)	Person responsible (Fix)	Date of completion (Fix)	Comments (Evaluate)
1.	Loose Electrical Connections (MCU)	Tightening of Connections	Electrician	8.12.2016	Done
2.	Worn out Cable (Electrical panel)	Replacement of cable	Electrician	9.12.2016	Done
3.	Mice or Insects inside the Panels	Sealing of Casing	Electrician	10.12.2016	Delayed

9

Job Safety Analysis (JSA)

Job safety analysis (JSA) helps integrate accepted safety and health principles and practices into a particular task or job operation.

In a JSA, basic procedure of O&M job,

- Potential hazards are identified & evaluated
- Control measures are recommended for the safe job operation

It is assessed by evaluating the probability of occurrence of hazard during a job or task, in terms of priority rating and the hazard coding

10

Probability

The extent to which a hazard may cause harm.

Probability Rating

Probability	Rating	Comments
Frequent	5	Workers are frequently at risk
Probable	4	The hazard is likely to cause harm
Occasional	3	Workers are occasionally at risk
Possible/remote	2	The hazard could cause harm, but is unlikely to do so.
Improbable	1	The hazard is unlikely to cause harm.

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Severity

This is the seriousness of the harm that could result from contact with a hazard. It is rated thus:

Severity	Rating	Comments
Catastrophic	5	Death and/ or severe destruction
Critical	4	Serious illness, injury, disability and significant property damage
Serious	3	Lost time injury and property damage
Marginal	2	Minor injury and property damage
Negligible	1	No injury and/or property damages

12

Priority level of Hazard is obtained from multiplication of the Probability and Severity ratings

Hazard =Probability x Severity

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

13

Hazard Coding

This is based on the outcome of the hazard factor obtained from the multiple of probability and severity.

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

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Example : Electrical Facility - Job Safety Analysis (JSA)

Location:	Tube well 4-D1, Green Town Sub Division									
Date:	December 9th, 2016									
Conducted By:	Sub Engineer, Electrician and Tube well Operator									
Sr. No.	**Hazards Identified**	**Hazards Type**	**Probability Ratings**	**Severity Ratings**	**Priority Rating**	**Action Needed**	**Assigned to**	**Due Date/ Time**	**Date Completed**	**Comments**
1	Thermal Relay Bypass	Motor winding damage	3	4	12	Replace relay and adjust values as per design	Electrician	8-12-16	9-12-16	New relay purchased and installed
2										
3										
4										
5										

Priority rating is obtained from multiplication of the Probability and Severity ratings (Hazard = Probability x Severity)
(range is between 1 -25, 1 being the lowest and 25 is highest priority)
JSAs are done for a specific task prior to the commencement of all major tasks involving any hazards or risks.

Personal Protective Equipment (PPE)

Equipment worn by employee to minimize exposure to hazards.

Criteria to choose PPE

1. **Ideally PPE should eliminate or mitigate risk associated with the hazard**
2. **Should be physically comfortable as much as possible**
3. **Should be in compliance to OSHA, ILO or any local standards/regulations**
4. **Should be right fit for the user**
5. **Should be in good working condition**
6. **Should be easily accessible**

Identified Personal Protective Equipment (PPE)

1. Safety Vest
2. Apron (for repair & maintenance)
3. Insulated gloves (Electrical Safety)
4. Heat insulated gloves
5. Safety helmet
6. Safety shoes
7. Face mask







Maintenance of PPE

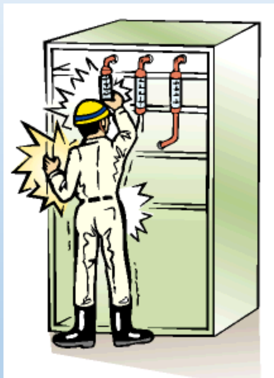
Effective procedure of maintenance & cleaning

1. **Manufacturer's maintenance schedule (including recommended replacement periods and shelf lives)**
2. **Inspection of PPE before each use (With most PPE, it only takes few minutes to inspect the equipment for any breaks, tears and visible signs of stress or damage)**

Maintenance include:

1. **Ease of access and availability**
2. **Validation (not expired)**
3. **In good working condition**
4. **Ample stock**

Major hazards related to Electrical Facility



Electric shock

Electric fire

19

CLASSES OF FIRE

Class A – For Ordinary combustibles such as wood, paper, and trash

Class B – For Flammable liquids such as gasoline, xylene, and alcohol

Class C – For Burning gases such as propane, methane, butane

Class D – For Metals such as Aluminum, Magnesium, Titanium

Class E – Fire involving potentially energized electrical equipment

Class F – For Cooking Oil

20

Fire Fighting

Fire prevention practices are attained by:

- Keep passage ways and exits clear
- Ensure fire extinguishers and fire alarm pull stations are accessible
- Place trash in proper receptacles
- Ensure that fire doors are not blocked
- Enforce No Smoking policy

21

Firefighting

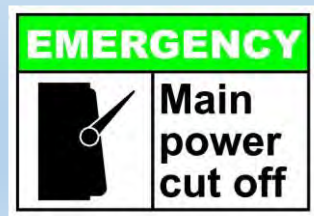
If Fire extinguisher containing carbon dioxide or halon are not available then

- Sand buckets may be used.
- Sand may cause a lot of mess.
- If sand buckets are not available then
- As a last resort sand may be kept in a polythene bags

22

In case of Fire . . . .

- Remain calm. Don’t panic.
- Shout “Fire”.
- Proceed safely to nearest passage
- Check passage carefully and leave
- Crawl to leave if smoke is present in area
- Shut off the power supply



23

Electrical Fire Safety

☠Do not use water to Extinguish electrical fire

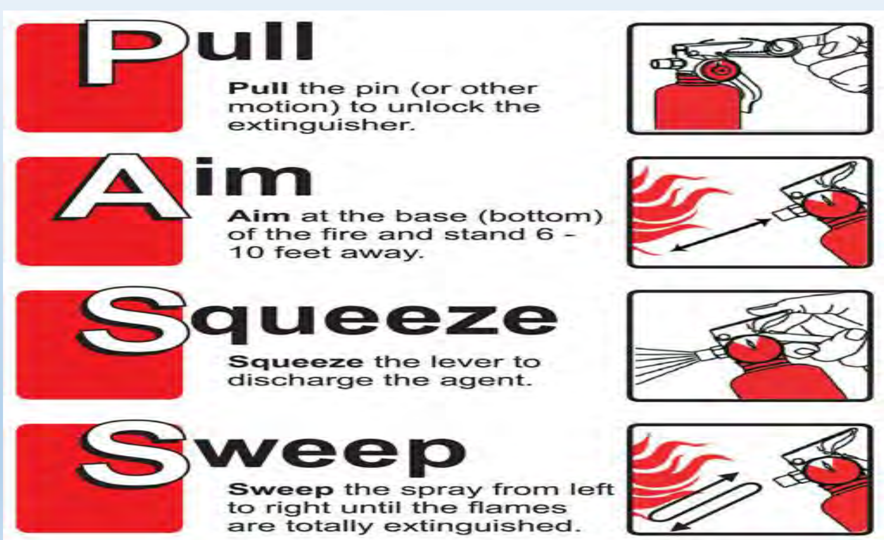
24

Always remember

To use **"Class "E"** fire extinguisher in case of energized electric equipment.

25

Steps of using fire Extinguisher



26

Record of Test & Inspection of Fire Extinguisher

Date	WASA facility	Fire extinguisher type & No.	Condition of fire extinguisher	Signature of Inspector	Action Taken	Signature of Supervisor
13.4.17	Tube well J3 Johar Town	CO_2 # 58	Filled and sealed		Verified	
13.4.17	Disposal station Johar Town	CO_2 # 65	Damaged paint, broken seal and empty		Apply paint, needs filling and sealing	

27

Low Voltage Rescue Kit

It is safety kit for technician or operator who are working on electrical panel, 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.**

28

Electric Shock

- The Human body is a good conductor of Electricity
- Direct Contact with electric current can kill
- When an electric current passes through body it destroys the muscles, nerves & tissues
- It can cause burns or even the affect the functioning of heart
- First try to ensure the isolation by switching off the mains
- If the current can not be turned-off , use low voltage crook or a non-conducting objects such as broom , rug or rubber mat to push or rubber door mat to push the victim away from the source of the current
- **Do not use a wet object or metal object for detachment of Electric shock victim**

29

Electric Shock

- Once the victim is free from the source of electricity , check the victim if in smoldering state then put fire blanket starting from the skull and moving towards the legs
- Check the victim's breathing & pulse and apply CPR
- If the victim has a burn, remove any clothing that comes off easily & apply burn cream or trauma dressing upon burnt area
- Call RESUE 1122

30

Electric Shock Video

31

Cardiopulmonary Resuscitation

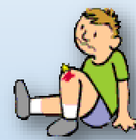
Three important steps are

Check
Call
&
Care

32

Check , Call & Care

Once you have followed the first two C's, you may need to give care until Rescue 1122 personnel arrive. Follow guidelines:



- ✓ Move an injured person ONLY if the scene is unsafe
- ✓ You need to reach someone more seriously injured, or you need to move the person to give care.
- ✓If a person is in shock, DO NOT give water.
- ✓ Help the person rest in the most comfortable position.

33

Is person responsive?

Check the victim for a response

If no response

CALL Rescue 1122

34

Open the airway & Maintain

Head tilt and chin lift

35

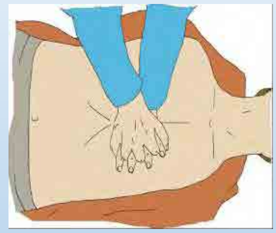
Check for breathing

**Look listen and feel for normal breathing and
LOOK FOR SIGNS OF LIFE for more than 10 seconds.**

36

Land mark

press down on the sternum 1 ½ to 2 inches



Place the heel of one hand in the center of the victim's chest

Place the heel of your other hand on top of the first hand

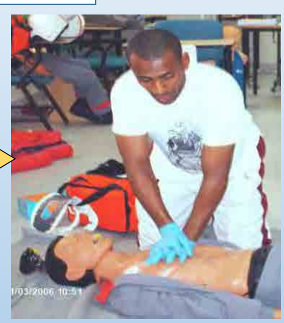
37

If no signs of life are present

Start Chest Compression

30 / 2

push hard and push fast



- ✓ After 30 compressions open the airway again using head tilt and chin lift give two breaths while watching the chest rise
- ✓ Rescue Breaths should last for 1 second.
- ✓ Do not stop CPR to check for signs of life until RESCUE 1122 arrive

38

Electrical Safety Rules

- ✓ Read & follow standard operating procedure for the function of each electrical component
- ✓ Prior turning on inspect electrical component for damage
- ✓ Never work alone
- ✓ Turn off the main supply and confirm with your own eyes
- ✓ Damaged or defective components must be removed
- ✓ Do not forget to check the presence of electricity using probe tester before O&M
- ✓ Maintain sufficient access around electrical equipment for O&M
- ✓ Always wear insulation gloves and use insulation sheet working with electrical components

39

Electrical Safety Rules

- ✓ Do not use electrical cord or extension wire during operation and maintenance
- ✓ If yellow plastic sheet is found during the progress of excavation works, immediately stop the excavation work
- ✓ When flooding occurs, do not enter flooded area where electrical equipment are submerged under water
- ✓ Measure the insulation resistance of all cables and equipment. Insulation resistance should be high enough before reapplying electricity to operate the equipment
- ✓ Do not touch or repair any machine/equipment until completely stop

40

First Aid Box

Accessories

- Panadol
- Dichloron
- Sterile gauze pads
- Adhesive tape
- Dressings (3″ & 6″)
- Zinc Oxide Adhesive Plaster
- Antiseptic cream
- Antibiotic ointment
- Piodine solution
- Quench cream for burn
- Tweezers
- Splint
- Scissors
- Thermometer
- Eye wash solution

Always examine expiry date before use.

41

First Aid Box Log Book

Work place	Log book #	Month	First Aid Kit #	Maintained by
Johar town tube well J3 block	JT-TW 1 / 2017	January	5	Muhammad Aslam, Sub Engineer

Sr.#	Date/ Time	Location	Name of injured	Type of Injury	First Aid given (Qty)	Situation	Outside treatment required
1	10.4.17 9:00am	Near delivery pipe	Muhammad Yaseen	Cut	Piodine (5ml), swab (1 no), mycitracin (10gm) & bandage 3″ (1 no.)	Cleaning ball valve	No
2	11.4.17 1:00pm	Tube well room	Khalid Munir	Deep cut	Piodine (10ml), swab (1 no), mycitracin (20gm) & bandage 6″ (1 no.)	Cleaning metallic base plate	Yes

42

Accident or Incident Report

Accidents or incidents are the part and parcel of repair and maintenance of Electrical installations.

- May be minor for example bruising or minor cut or major.
- May need hospitalization or compensation

Recording and documentation of accident and incident is necessary.

43

Accident / Incident Report

Reported to____________________________

Reported Date 13th April 2017

Reported by Ihsan Ul Haque Javed

1. Status of Accident / Trouble

Date of Accident	8 Dec 2016
Place	Lift pump room, Academy Disposal Station
Person involved	Operator: Zain
Equipment involved	Electrical Panel for No.3 Lifting Pump
Current Condition (Person/Equipment)	・No persons injured ・1 magnetic contactor of the starter circuit is burnt out even though No.3 pump is operational somehow.
Incident in detail	Several minutes after the operator starts the pump as usual in the afternoon, he found some smoke and burnt smell around the panel. He immediately stopped the pump by emergency stop button.
Possible Causes	・Setting value of the thermal relay was set at maximum. ・Loosen terminals ・Continuous low voltage from WAPDA

44

2. Countermeasure

Action to be taken	・Replace the burnt magnetic contactor with new one. ・Check the availability of the other 2 contactors and cables, then replace them if necessary ・Change the setting value of thermal relay from maximum value to 160A, which is the rated current of motor. ・Check the setting value of U/O voltage relay and adjust it if necessary ・After the work above, confirm retightening of all bolts in the panel
Resources required	・Electrician for the panel arrangement ・1 magnetic contactors If necessary: 2 more magnetic contactors, thermal relay
Due Date	15/04/2017
Person in charge	Jawad Shahid

3. Remarks

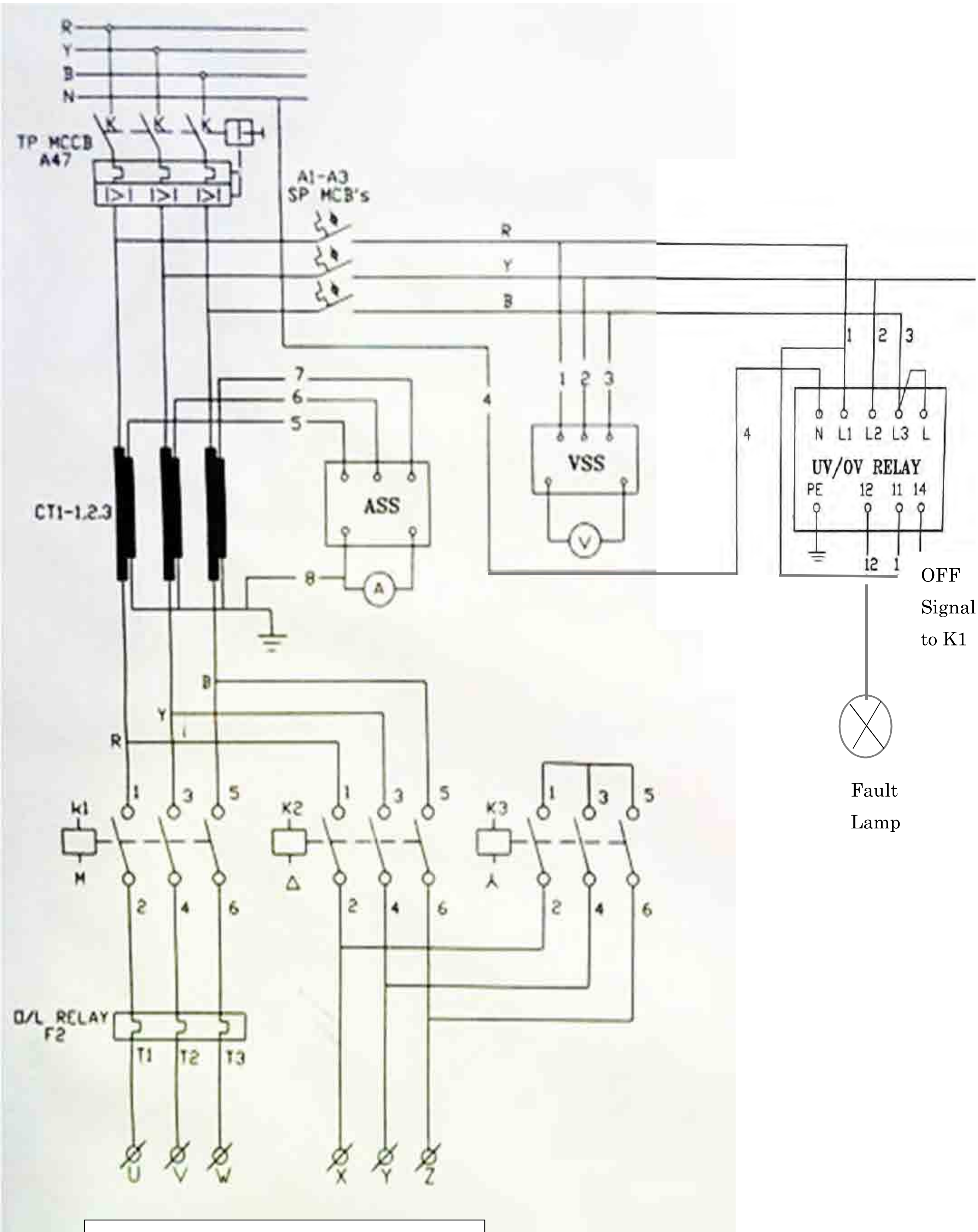
Already arranged the repair working day with the electrician. We will confirm the availability of the devices mentioned above on 13th April. I will finalize and report the required item list to you by 15th April.

45

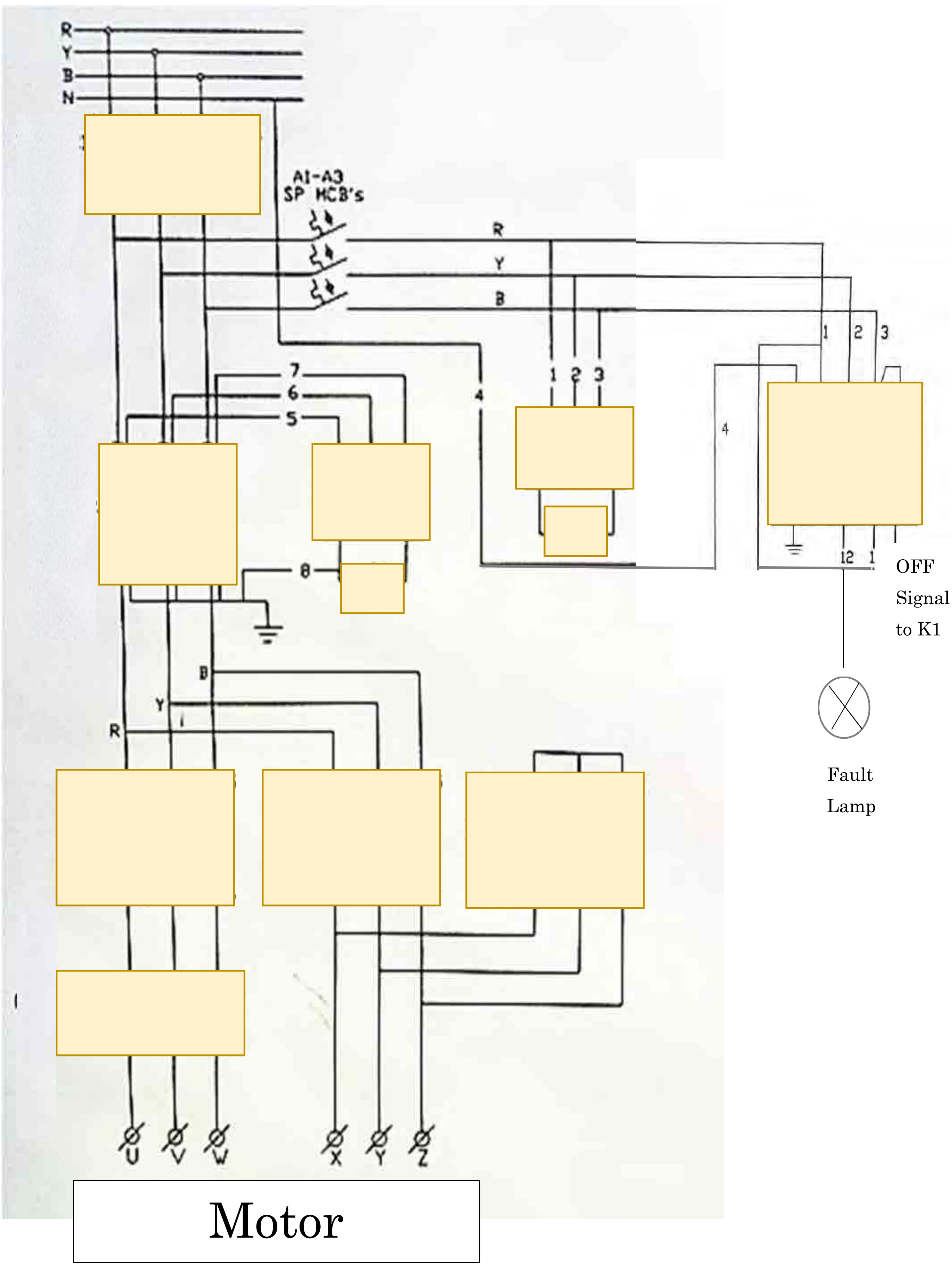
Contact Information

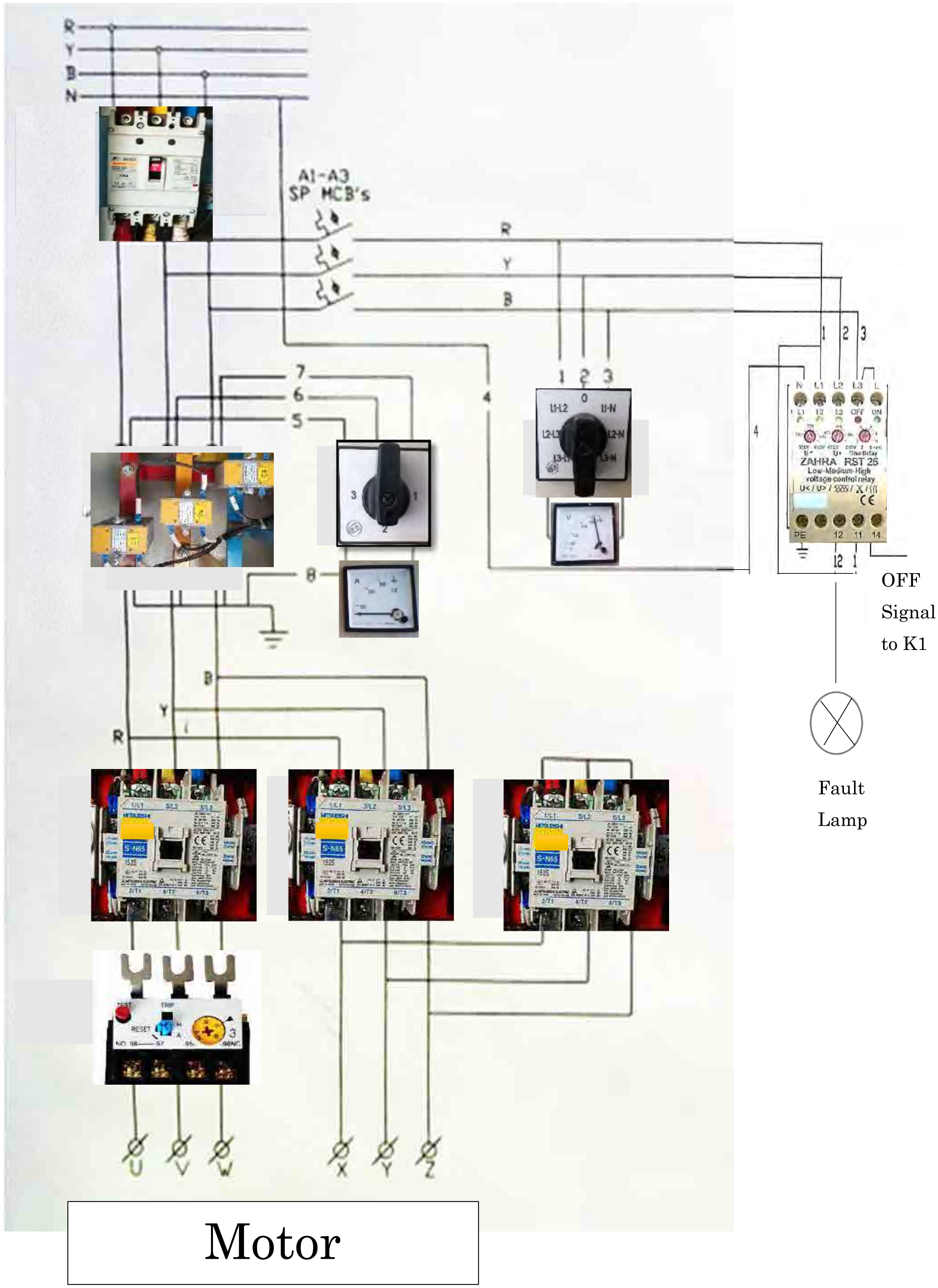
Faculty Names	Contact Information
JICA Expert **Akira Hasebe (Electrical)**	
Course Leader **Mubasher Ahmad Cheema**	
Sr. Instructor (Environment) **Ihsan-ul-haque Javed**	
Sr. Instructor (Electrical) **Jawad Shahid**	
Young Professional **Tanveer Shahzad**	

46


R
Y
B
N
TP MCCB
A47
A1-A3
SP MCB's
CT1-1,2,3
ASS
A
VSS
V
UV/OV RELAY
N L1 L2 L3 L
PE 12 11 14
OFF
Signal
to K1
Fault
Lamp
K1
M
K2
Δ
K3
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
1 2 3
7
6
5
4
1 2 3
4
8
OFF
Signal
to K1
12
1
B
Y
R
Fault
Lamp
U V W X Y Z
Motor

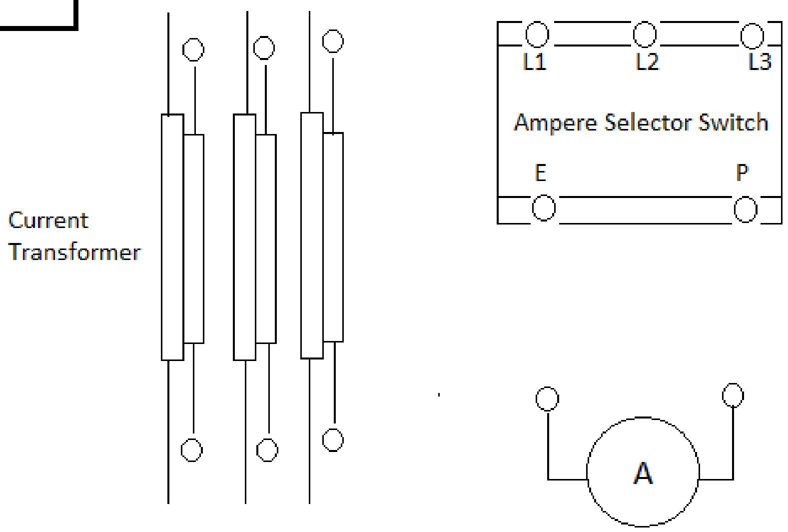

R
Y
B
N
A1-A3
SP MCB's
R
Y
B
1
2
3
4
7
6
5
8
L1-L2
L1-N
L2-L3
L2-N
L3-L1
L3-N
ZAHRA RST 25
Low-Medium-High
voltage control relay
OFF
Signal
to K1
Fault
Lamp
B
Y
R
S-N65
U
V
W
X
Y
Z
Motor

Control Panel Advance Activity 1

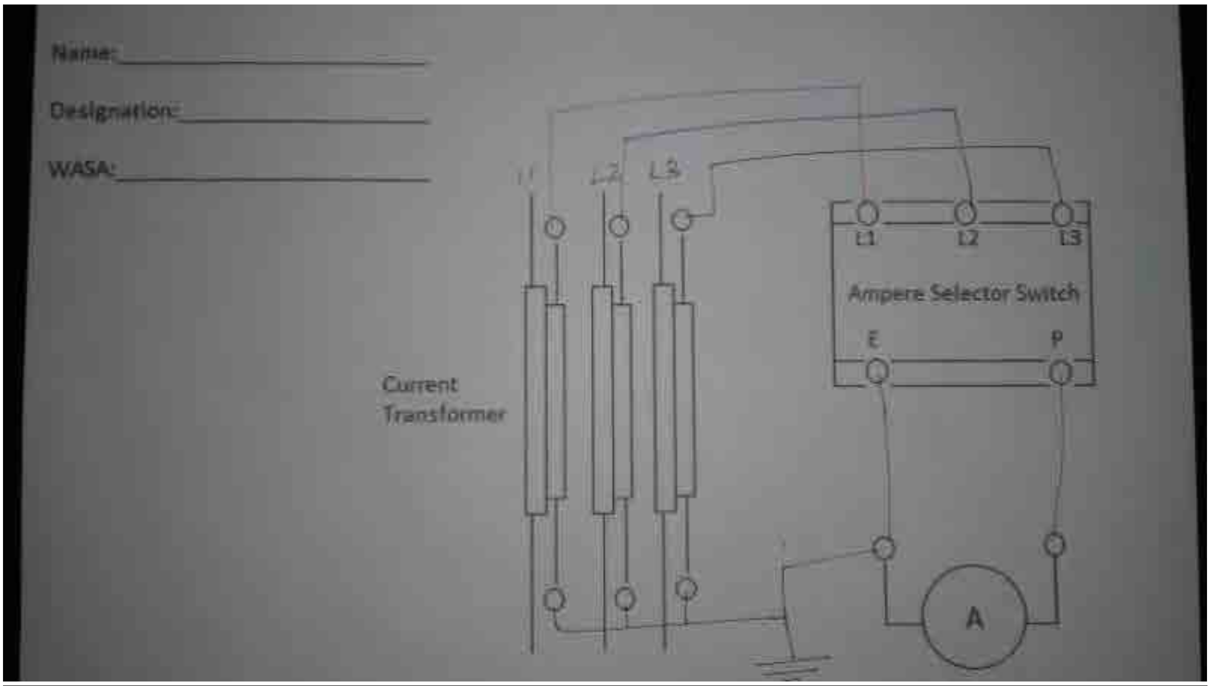
Name:______________________________

Designation:________________________

WASA:______________________________



Control Panel Advance Activity 1 Solution

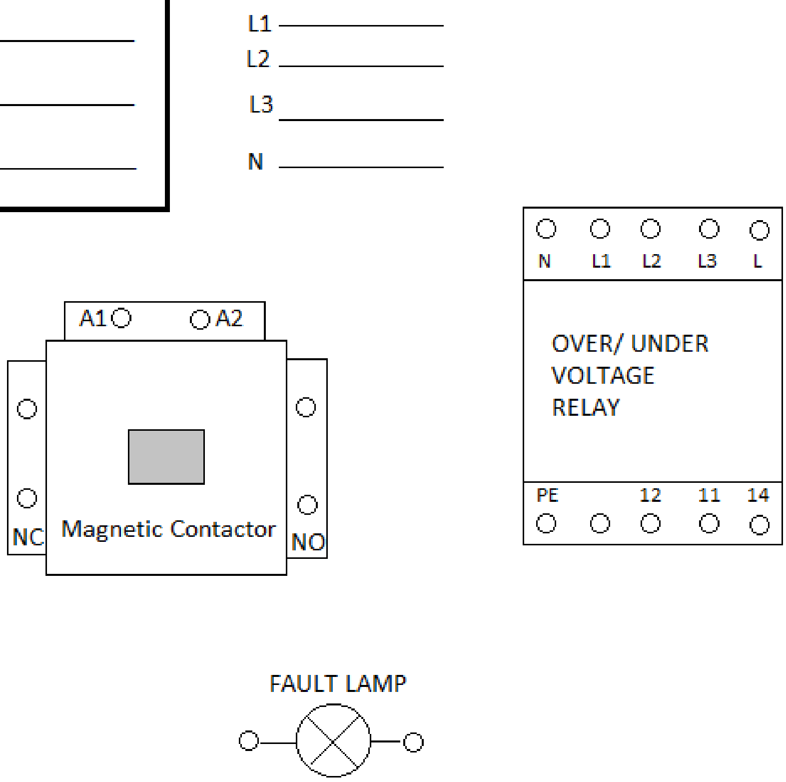


Control Panel Advance Activity 2

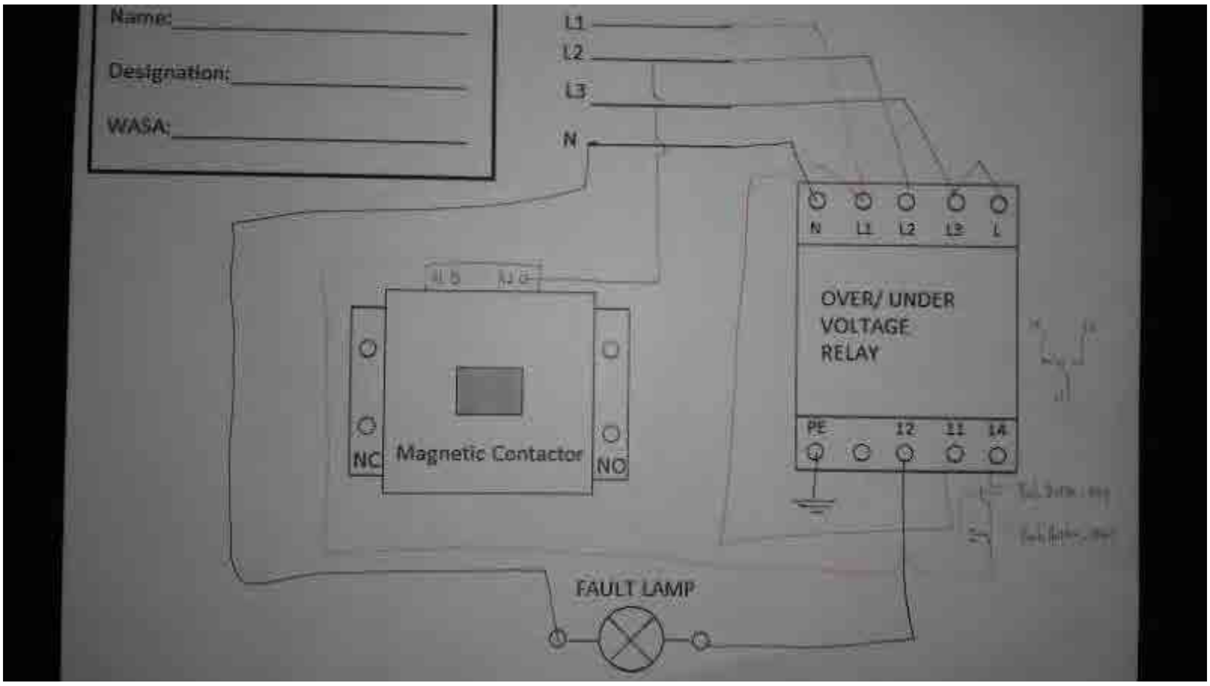
Name:________________________________

Designation:__________________________

WASA:________________________________



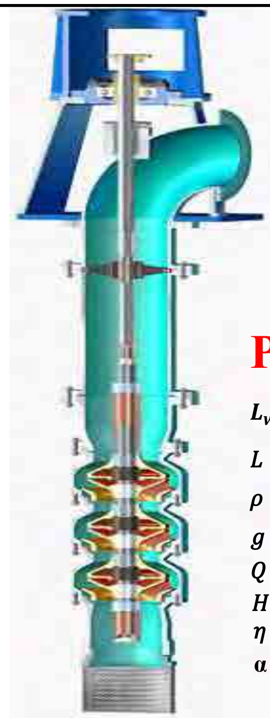
Control Panel Advance Activity 2 Solution



Name:________________

Module 1, Exercise 2

Question:
Please calculate required motor size (power) for the given pump parameters.



P (motor) = ?

L_w : Liquid Power

L : Shaft Power

ρ : Water density 1000 kg/m^3

g : Gravity acceleration on Earth 9.81 m/s^2

Q : Capacity/Discharge 0.111 m^3/s

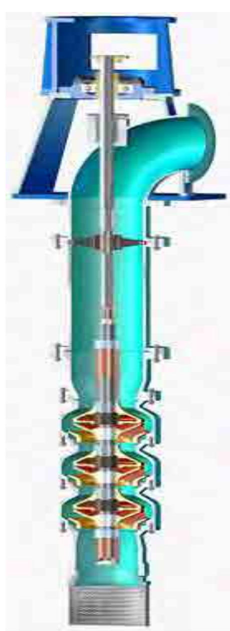
H : Total head 60 m

η : Pump Efficiency = 0.85

α : Power allowance = 0.13

Module 1, Exercise 2

<Formulas>



$$L_w\,(\text{kW}) = \frac{\rho g Q H}{1000}$$

$$\text{L (kW)} = \frac{(L_w)}{\eta}$$

$$\text{P (motor)} = \text{L}(1+\alpha)$$

L : Shaft Power

L_w : Liquid Power

ρ : Water density 1000 kg/m^3

g : Gravity acceleration on Earth 9.81 m/s^2

Q : Capacity/Discharge 0.111 m^3/s

H : Total head 60 m

η : Pump Efficiency 0.85

α : Power allowance= 0.13 (0.10～0.20)

Module 1, Exercise 2

<Solution>

$$L_w\,(\mathrm{kW}) = \frac{\rho g Q H}{1000} = \frac{(1000)(9.81)(0.111)(60)}{1000} = 65.33$$

$$L\ (\mathrm{kW}) = \frac{(L_w)}{\eta} = \frac{(65.33)}{0.85} = 76.86$$

$$P\ (\text{motor}) = L(1+\alpha) = 76.86(1+0.13) = 86.85\ \mathrm{kW}$$

For example, select next size available, in this case it is 95 kW or 125 HP

kW	HP	kW	HP
0.25	1/3	26	35
0.4	1/2	30	40
0.5	2/3	33	45
0.55	3/4	37	50
0.75	1	45	60
1.1	1.5	55	75
1.5	2	60	80
2.2	3	75	100
3	4	95	125
3.7	5	110	150
5.5	7.5	150	200
7.5	10	190	250
11	15	220	300
15	20	260	350
18.5	25	300	400
22	30	370	500

Operation Time Record (Pump)

Approved by (Engineer)	
Prepared by (Operator)	

Month/Year : /

Date : ~

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:

Operation Time Record (Pump)

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	08-Apr-17	2	#######	04:15 PM	2	Y	-	-	-	0.2	0.79	402	408	405	125	120	122
2		2	#######	07:15 PM	2	Y	-	-	-	0.2	0.8	398	402	401	127	122	123
3		3	#######	11:15 PM	3	N	-	-	-	0.2	0.77	404	410	407	123	119	122
4	09-Apr-17	1	#######	########	4	Y	-	-	-	0.2	0.81	400	406	401	126	124	125
5		2	#######	04:15 PM	2	Y	-	-	-	0.2	0.79	402	408	405	125	120	122
6		2	#######	07:15 PM	2	Y	-	-	-	0.2	0.8	398	402	401	127	122	123
7		3	#######	11:15 PM	3	N	-	-	-	0.2	0.77	404	410	407	123	119	122
8	10-Apr-17	1	#######	########	4	Y	-	-	-	0.2	0.81	400	406	401	126	124	125
9		2	#######	04:15 PM	2	Y	-	-	-	0.2	0.79	402	408	405	125	120	122
10		2	#######	07:15 PM	2	Y	-	-	-	0.2	0.8	398	402	401	127	122	123
Total/ Sum					26				-								

Remarks: Bulk flow meter is not operational and need to be replaced.

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

Approved by :

Inspected by :

Motor Specification: **Rated Capacity (kW/HP)** 55kW .

Rated Voltage (V) 400 V **Rated Current(A)** 101A .

Efficiency 92.1 % **Power Factor** 0.86 **RPM** 1478 .

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	Tube well 4-D1	8-Apr-17	△	✓	×	✓	✓	✓	✓	✓	✓	△	△	✓	✓	✓	✓
2	Tube well 4-D1	10-Apr-17	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3																	

- Remarks -

Operation record should include Current and Voltages values 8/4
Manual should be placed after getting it from the manufacturer 8/4
Webs should be removed 8/4
Base plate should be installed 8/4
We have contacted manufacturer of panel for manuals and we'll place the manuals as soon as we get. Rest of issues are resolved. 10/4

Device Inspection Sheet

Approved by :

Inspected by :

<u>Motor Specification:</u> **Rated Capacity (kW/HP) __________**

Rated Voltage (V) _____Rated Current(A) ______Efficiency_____

Power Factor_______RPM_________

<u>Evaluation Criteria</u>

✓ : 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 -

Device Inspection Sheet

Approved by :

Inspected by :

Motor Specification: **Rated Capacity (kW/HP)** 55kW .
Rated Voltage (V) 400 V **Rated Current(A)** 101A .
Efficiency 92.1 % **Power Factor** 0.86 **RPM** 1478 .

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	Tube well, 4-D1	10-Apr-17	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓	✓	✓	✕	✕	✓
2																				
3																				
4																				
5																				

- Remarks -

Fuses are not required as per design 10/4
Over current relay is not working 10/4
Current transformers will be checked within three days 10/4

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)**	**-**	**-**	

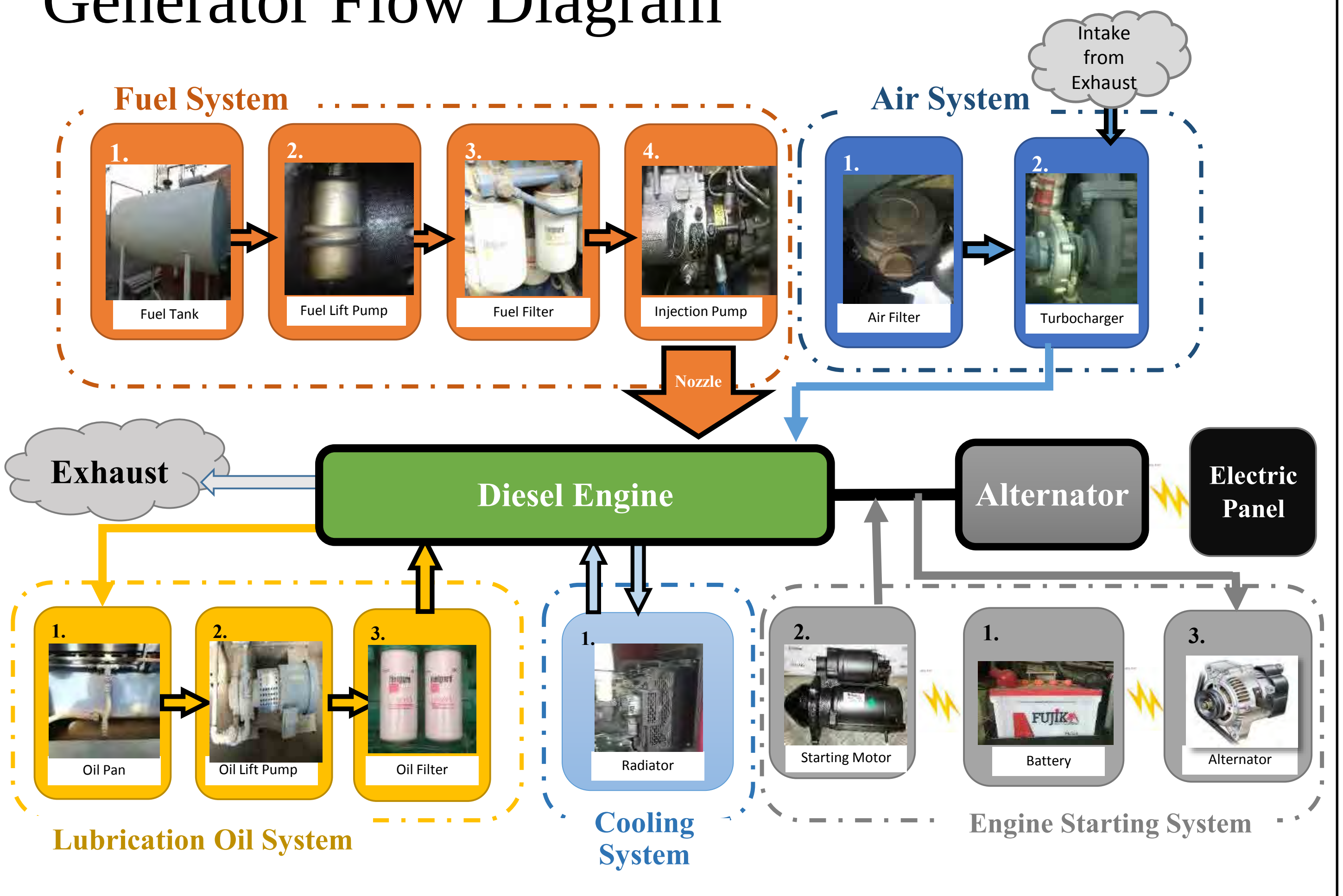
Date						
Inspected By						
Weather						
Bolt Tightening						
Insulation Resistance (MΩ)	U1-E	U2-E				
	V1-E	V2-E				
	W1-E	W2-E				
	U1-V1	U2-V2				
	V1-W1	V2-W2				
	W1-U1	W2-U2				
Voltage by Clamp Meter (V)	RY					
	YB					
	BR					
Ampere by Clamp Meter (A)	R					
	Y					
	B					
Power Factor						
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

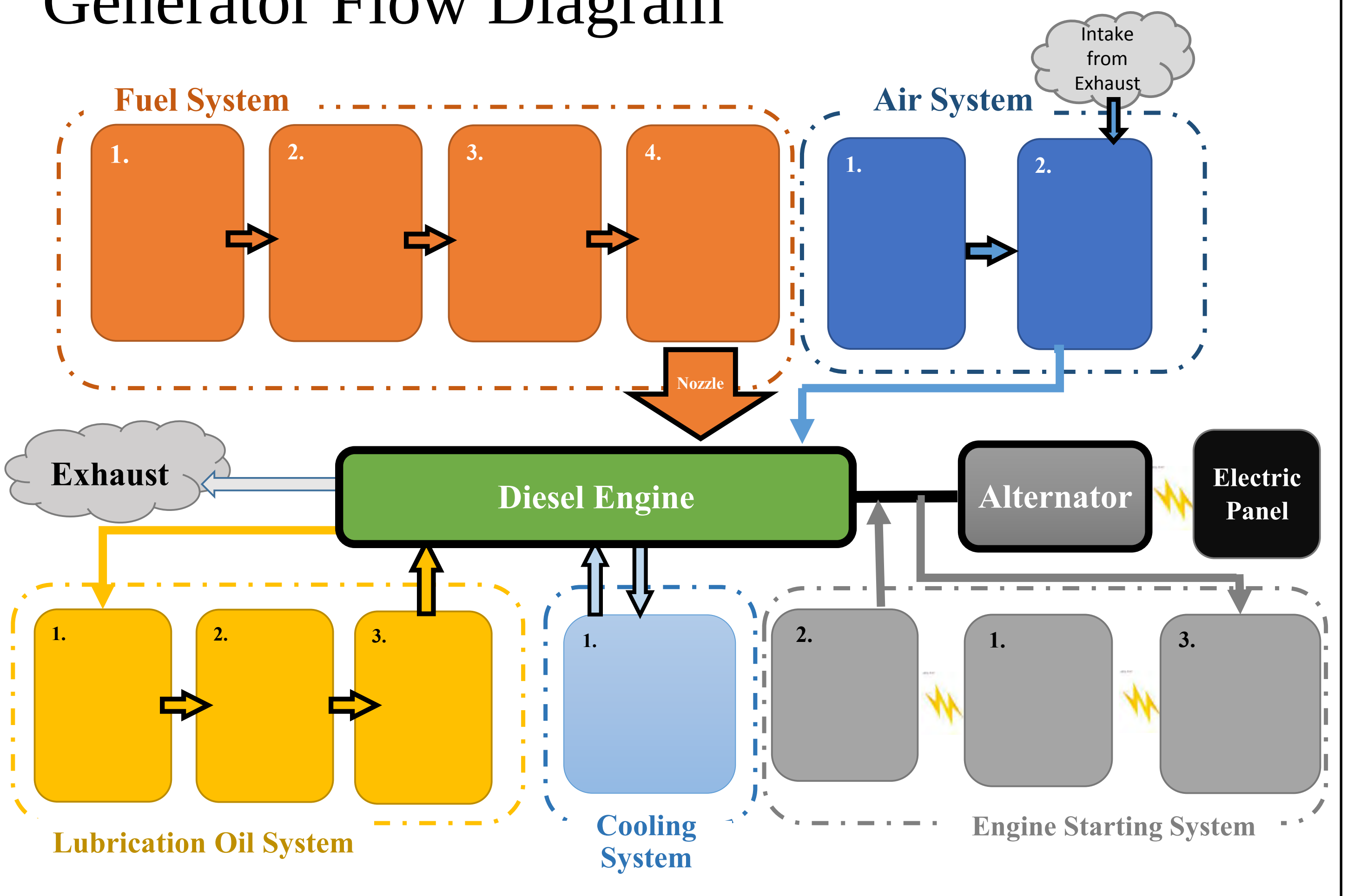
Need to Adjust, Clean,Care → 1.0MΩ ~ 0.4 Need to repair immediately →less than 0.4MΩ

- Remarks -

Generator Flow Diagram



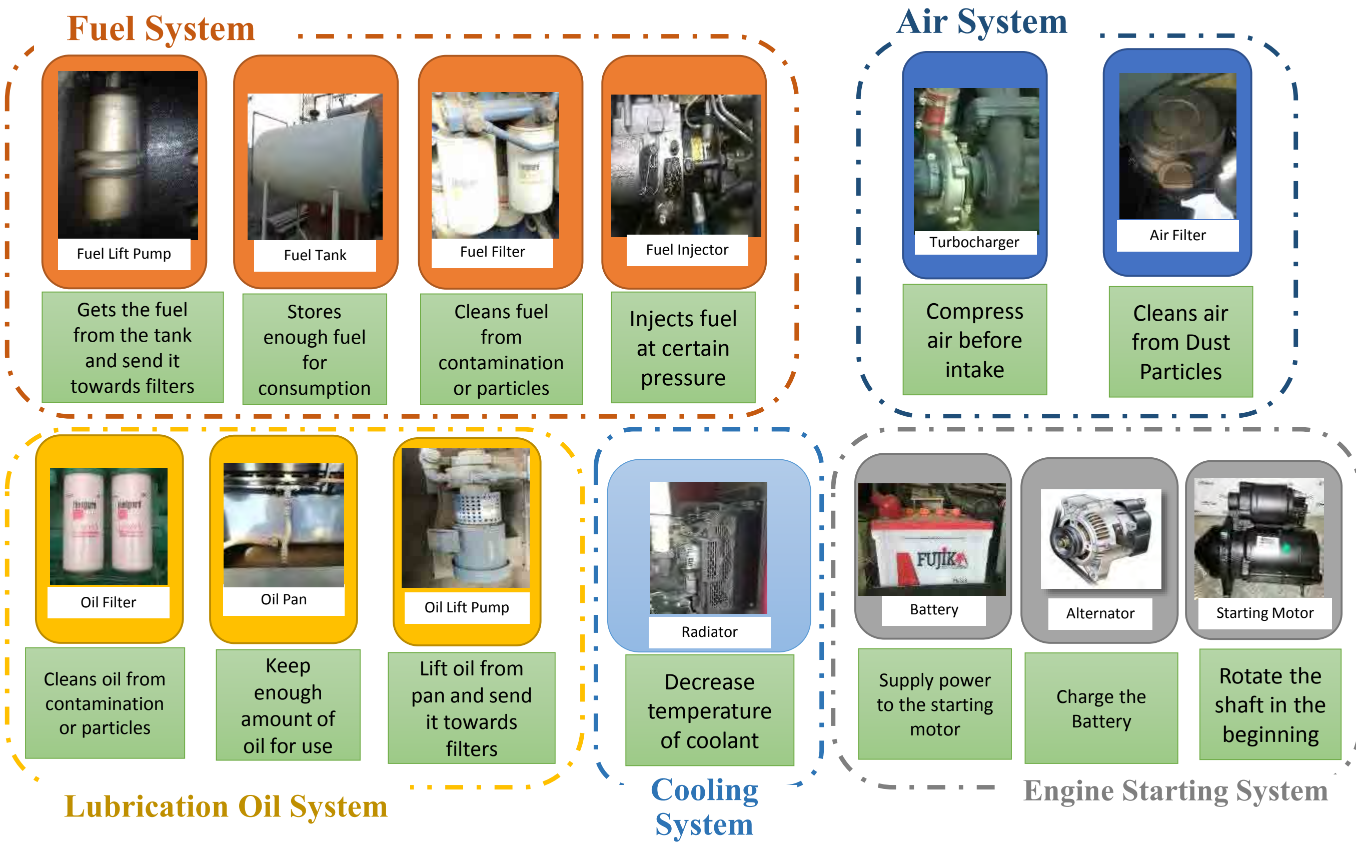
Generator Flow Diagram



Name of Participant: ___________________________________

Components for Engine

(Solution)



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

Generator Annual Maintenance Plan (Sample) **-Year 2017-**

Legend : Plan "●", Done "✓"

First Setting for Trial Activity

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

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

Ｉｔｅｍ	2017								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Operation Hours of the Month									
Total Operation Hours									

Item	**Required maintenance cycle**	**Product to be required**	**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
			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 ____________ hours	**Electrolyte**																		
Engine Air Cleaner Element – Clean/Replace	Every ____________ hours	**Air Cleaner Element**																		
Engine Oil and Filter – Change	Every ____________ hours	**Engine Oil Filter**																		
Fuel System Filter Element - Replace	Every ____________ hours	**Fuel Filter**																		
Hoses and Clamps – Inspect/Replace	Every ____________ hours	**Hoses, Clamps**																		
Engine Valve Lash – Inspect/Adjust	Every ____________ hours																			
Specific gravity of electrolyte of battery	Every ____________ hours	**Hydrometer**																		
Alternator – Inspect	Every ____________ hours																			
Engine Mounts – Inspect	Every ____________ hours																			
Starting Motor – Inspect	Every ____________ hours																			
Cooling System Coolant – Change	Every ____________ hours																			

Generaotr Annual Maintenace Plan (Sample) -Year 2017-

Legend : Plan "●", Done "✓"

First Setting for Trial Activity

Average Operation Time per day	2	hours/day
Average Operation Time per month (※30days)	60	hours/month

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

Item	2017											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Operation Hours of the Month	60	60	60	60	60	60	60	60	60	60	60	60
Total Operation Hours	**60**	**120**	**180**	**240**	**300**	**360**	**420**	**480**	**540**	**600**	**660**	**720**

Item	Required maintenance cycle	Product to be required	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			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																									

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											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			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																									

i05927155

Maintenance Interval Schedule

When Required

Daily

Every 50 Service Hours or Weekly

Every 500 Service Hours

Every 500 Service Hours or 1 Year

Every 1000 Service Hours

Every 2000 Service Hours

Every 2 Years

Every 3000 Service Hours

Every 3000 Service Hours or 2 Years

Every 4000 Service Hours

Every 6000 Service Hours or 3 Years

Every 12 000 Service Hours or 6 Years

i02322260

Aftercooler Core - Clean/Test

1. Remove the core. Refer to the OEM information for the correct procedure.

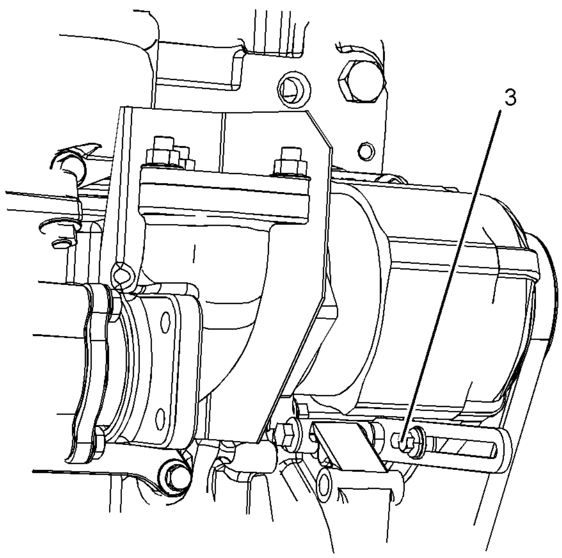


Illustration 31 g03716558

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).

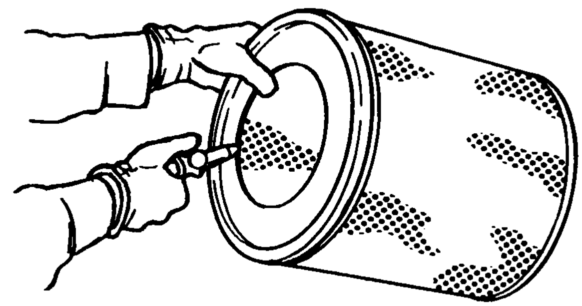


Illustration 38 g00281692

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

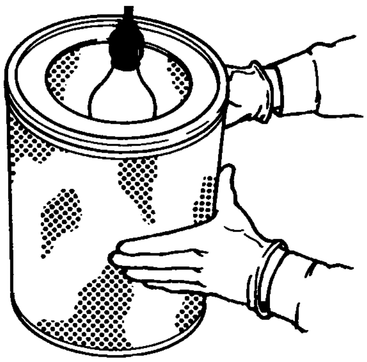


Illustration 39 g00281693

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.

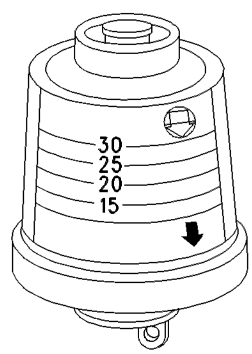


Illustration 40 g00103777

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.

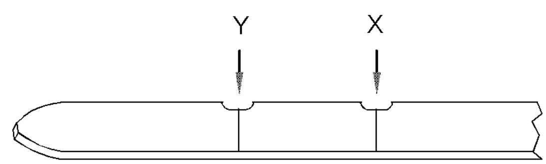


Illustration 41 g01165836

(Y) “Min” mark. (X) “Max” mark.

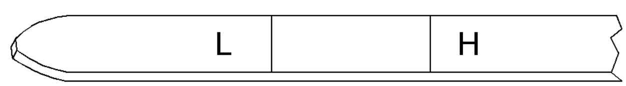


Illustration 42 g02173847

(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.

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

Daily Operation and Maintenance Record (Generator)

Month/Year :   /

Date :   ~

Approved by (Engineer)	
Prepared by (Operator)	

Sr. No.	Date	Shift #	Operation Record								Maintenance Record				
			Operating Time		Operating Hours	Voltage			Frequency	Energy Consumption	Coolant Level	Fuel Level	Engine Oil Level	Alternator and Fan Belts	Walk Around Inspection
			Turn On	Turn Off	Hrs.	RY 400V	RB 400V	BR 400V	Hz	KWh	✓	L	%	✓	✓
1															
2															
3															
4															
5															
6															
7															
8															

Remarks:

Legends:

OK : ✓

Not OK : X

Not Applicable : N

Can Not Check : -

Accident / Incident Report

Reported to____________________________ Reported Date___ 9 Dec 2016___

Reported by___ Jawad Shahid _____

1. Status of Accident / Trouble

Date of Accident	8 Dec 2016
Place	Lift pump room, Academy Disposal Station
Person involved	Operator: Zain
Equipment involved	Electrical Panel for No.3 Lifting Pump
Current Condition (Person/Equipment)	• No persons injured • 1 magnetic contactor of the starter circuit is burnt out even though No.3 pump is operational somehow.
Incident in detail	Several minutes after the operator starts the pump as usual in the afternoon, he found some smoke and burnt smell around the panel. He immediately stopped the pump by emergency stop button.
Possible Causes	• Setting value of the thermal relay was set at maximum. • Loosen terminals • Continuous low voltage from WAPDA

2. Countermeasure

Action to be taken	• Replace the burnt magnetic contactor with new one. • Check the availability of the other 2 contactors and cables, then replace them if necessary • Change the setting value of thermal relay from maximum value to 160A, which is the rated current of motor. • Check the setting value of U/O voltage relay and adjust it if necessary • After the work above, confirm retightening of all bolts in the panel
Resources required	• Electrician for the panel arrangement • 1 magnetic contactors If necessary: 2 more magnetic contactors, thermal relay
Due Date	15 Dec 2016
Person in charge	Jawad Shahid, Zain

3. Remarks

Already arranged the repair working day with the electrician. We will confirm the availability of the devices mentioned above on 13th Dec. I will finalize and report the required item list to you by 15th Dec.

Accident / Incident Report

Reported to______________________________ Reported Date____________________________

Reported by____________________________

1. Status of Accident / Trouble

Date of Accident	
Place	
Person involved	
Equipment involved	
Current Condition (Person/Equipment)	
Incident in detail	
Possible Causes	

2. Countermeasure

Action to be taken	
Resources required	
Due Date	
Person in charge	

3. Remarks

Job Safety Analysis (JSA)										
Location:										
Date:										
Conducted By:										
Sr.#	Hazards Identified	Hazards Type	Probability Ratings	Severity Ratings	Priority Rating	Action Needed	Assigned to	Due Date/Time	Date Completed	Comments

Priority rating is obtained from multiplication of the Probability and Severity ratings (Hazard = Probability x Severity) (range is between 1 -25, 1 being the lowest and 25 is highest priority)
JSAs are done for a specific task prior to the commencement of all major tasks involving any hazards or risks.

Firefighting Preparedness Questionnaire

Small Fire Involving Electrical Panel or Generator	
What facilities you need for firefighting?	
In case You are the First Finder, What You Can do or should not do to extinguish fire?	
To Whom You may contact in case of a fire emergency?	
Propose firefighting preparedness actions for Your work site?	
Suggest PPE and Equipment for firefighting?	

First Aid Box Log Book

Work place	Log book #	Month	First Aid Kit #	Maintained by

Sr.#	Date/ Time	Location	Name of injured	Type of Injury	First Aid given (Qty)	Situation	Outside treatment required
1							

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.

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:

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-

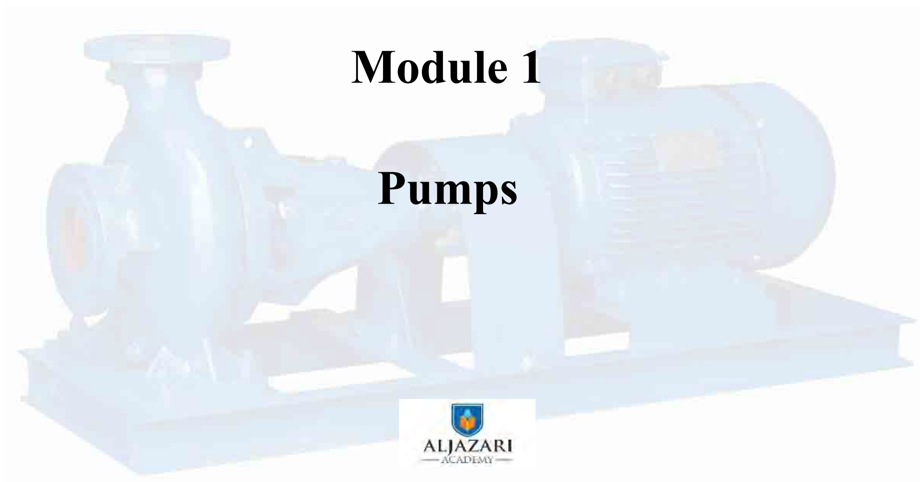
OJT Implementation Procedure for O&M Manual, Record Keeping and Preventive Maintenance Activity of Diesel Generator

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-

Annex 3.35
Training Material for O&M of Mechanical Equipment
in Spring 2017

O & M of Mechanical Equipment
WSD 5231



Module 1

Pumps

Topics to cover..

- ✓ Importance of equipment in WASA operations
- ✓ Selection criteria of pumps
- ✓ Assembly components

Topics to cover..

- ✓ Pump operations
- ✓ Preventive maintenance of pumps
- ✓ Troubleshooting of pumps

Icebreaker and Class Introduction

Now it is your turn…

- Degree and backgrounds?
- Share your work experience relative to WASA equipment?

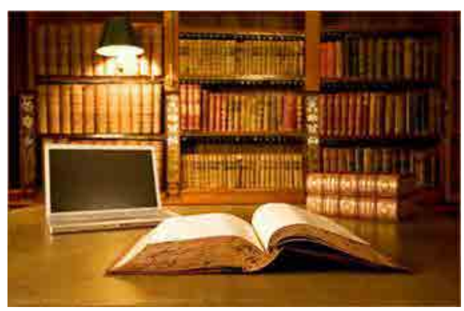
Brainstorming

Now it is your turn…

- Any prior experience on Pumps?
- Why interested in this Module?
- What best skills do you bring to the class?

Resources and Handouts

- Owner's Manual, KSB Pumps
- Pumps and Pumping (Arasmith, S. 2006)
  ACR Publications, London
- Participant lecture notes, Module 1
- Class presentations, Module 1



Resources and Handouts

- O and M of Pumps Manual
- JICA, Manual on sewerage and sewage treatment,

  Part B: Operation and Maintenance,

  Ministry of Urban Development, New Delhi

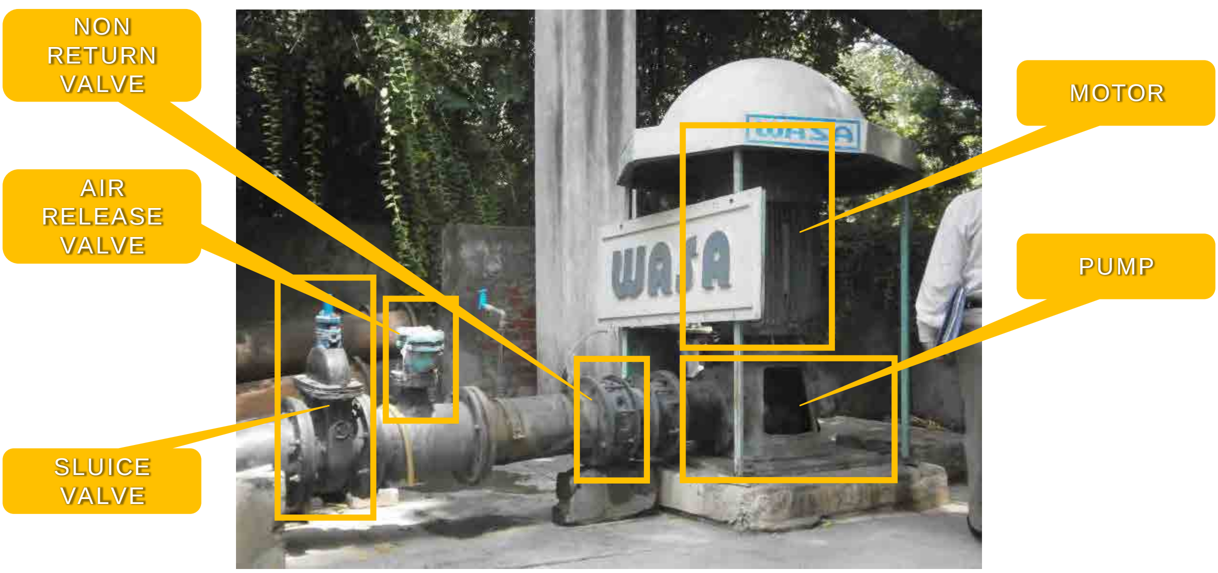
Importance of Tube Well Pumps

This could be my home !

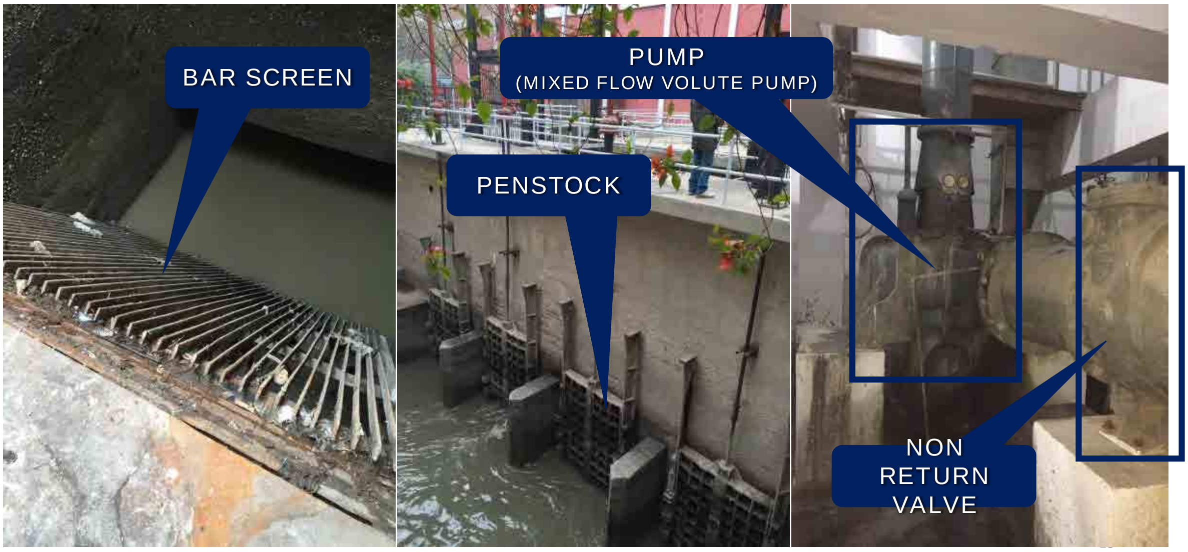
Importance of Disposal Station Pumps

This could be our children !

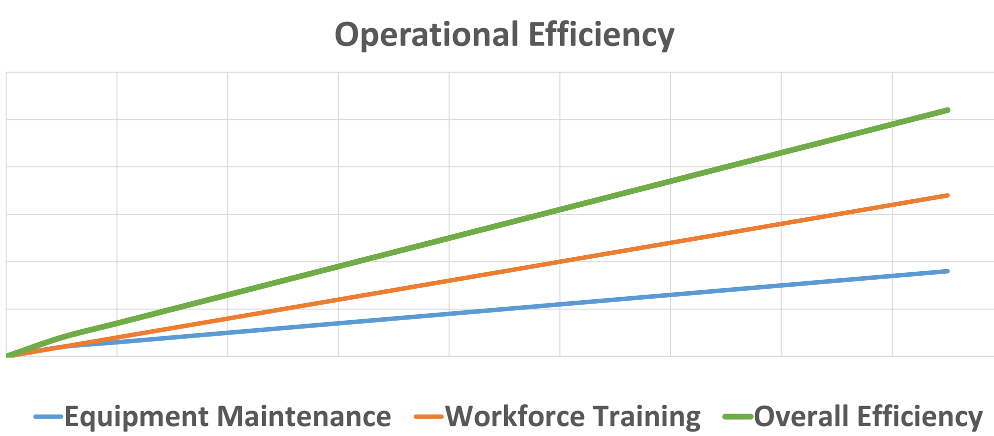
Introduction to Pumps (Tube Well)



Introduction to Pumps (Disposal Station)



Importance of Equipment Reliability and Trainings



Introduction to Pumps

Pump

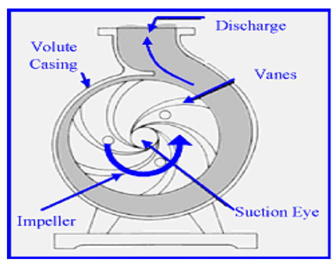
It is a mechanical device to transport liquids. It coverts kinetic energy into velocity/pressure.

Introduction to Pumps

Two major categories:

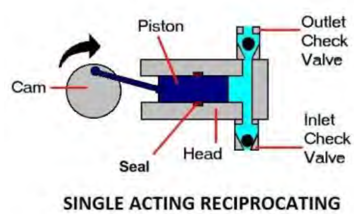
i) Centrifugal Pumps

The Pump in which energy is continuously added to increase the fluid velocities within the machine. This type is most commonly used in water and sanitation industry.



ii) Positive Displacement Pumps

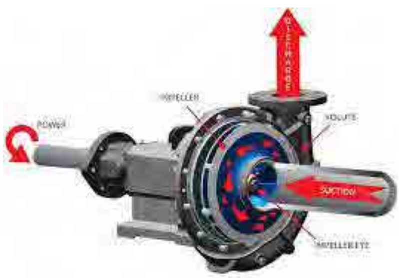
The pump in which the energy is periodically added by application of force.



Introduction to Pumps

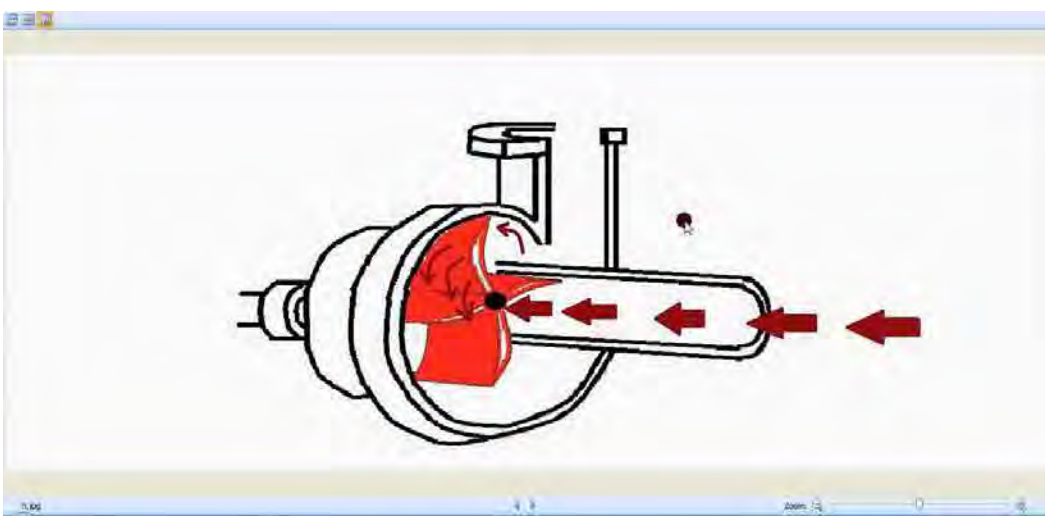
Centrifugal Pumps

Centrifugal pumps are used to transport fluids by the conversion of rotational kinetic energy to the hydrodynamic energy of the fluid flow. The rotational energy typically comes from an engine or electric motor.



Centrifugal Pump

Video Centrifugal Pumps



Introduction to Pumps

General Design and Parameters…

All equipment should be selected properly. Wrong selection will cause…

- ✓**Short lifecycle**
- ✓**Operational downtime**
- ✓**Energy loss**
- ✓**Major capital loss**

Selection Criteria of Pumps

How to select a pump?

How much water is needed?

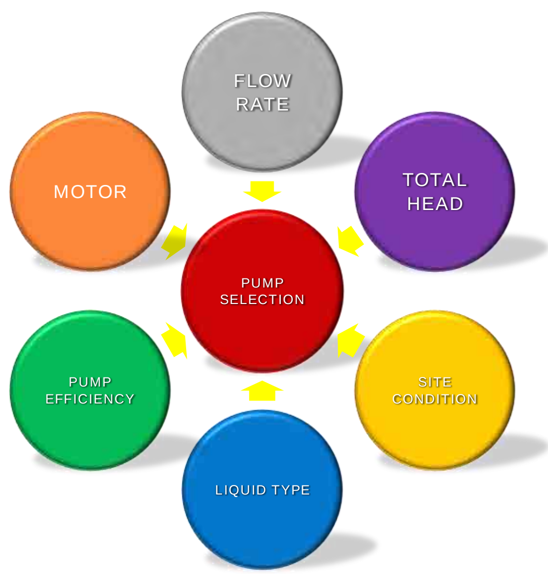
How far or high water will be delivered?

Is there a guaranteed pump efficiency need?

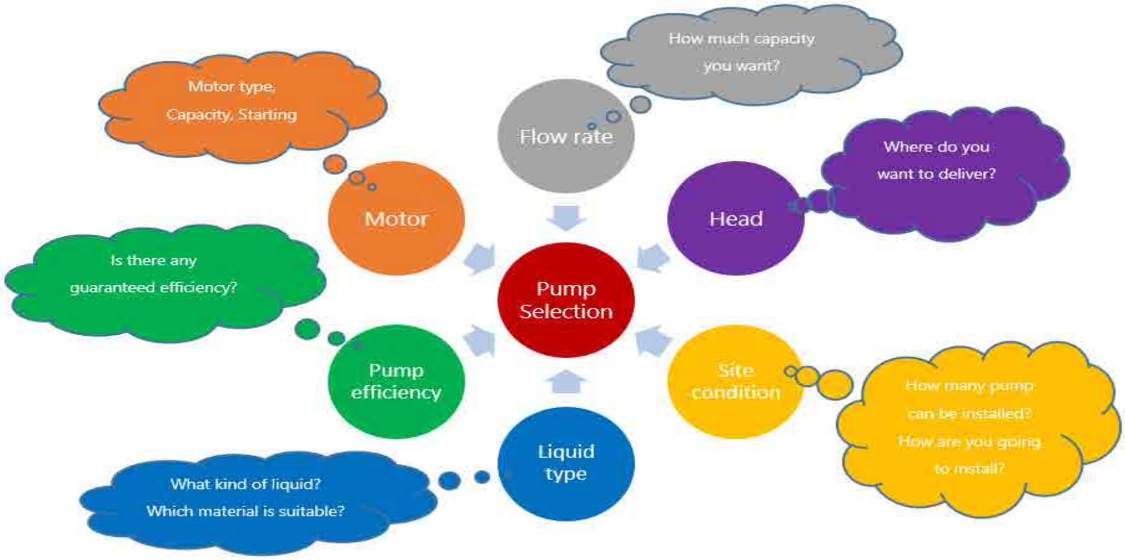
What kind of liquid is transported?

How much space is available for pump installation?

Motor/energy factor?



Selection Criteria of Pumps



Selection Criteria of Pumps

Parameters

- ✓Flow Rate [cusec, m3/h, l/s]
- ✓Total Head [m, ft.]
- ✓Motor Output [kW, HP]
- ✓Pump Type [water supply, wastewater)

Selection Criteria for Pumps

Other Parameters

- ✓**Materials [cast iron, steel, food grade]**
- ✓**Liquid Type [clean water, waste water]**
- ✓**Paint [anti corrosion]**
- ✓**Available Installation Space [m2, ft2]**

Introduction to Pump Design Basics

Pumping Concepts:

- ✓ Capacity (discharge rate required)
- ✓ Head (various)
- ✓ Pump performance curve
- ✓ Efficiency

Introduction to Pump Design Basics

Capacity

The capacity (flowrate) of a pump is the volume of liquid pumped per unit of time, which usually measured in meters per second or (gallons per minute GPM) or cusec (cubic foot per second)

In Water supply and sanitation agency,

Cusec (28.317 liters per second) is used to show the capacity of a pump.

Introduction to Pump Design Basics

Head

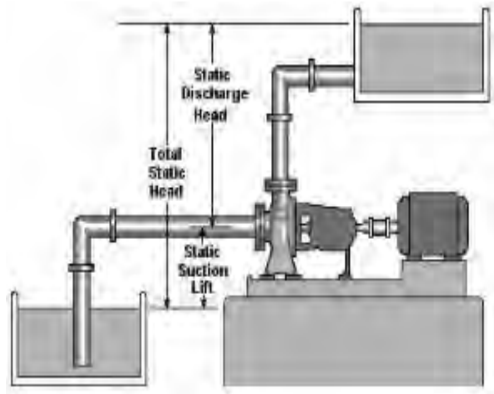
The following terms apply specifically to the analysis of pumps and pumping systems:

1) Static suction head (SSH)
2) Static discharge head (SDH)
3) Friction head
4) Velocity head
5) Total head (TH)

Introduction to Pump Design Basics

Head

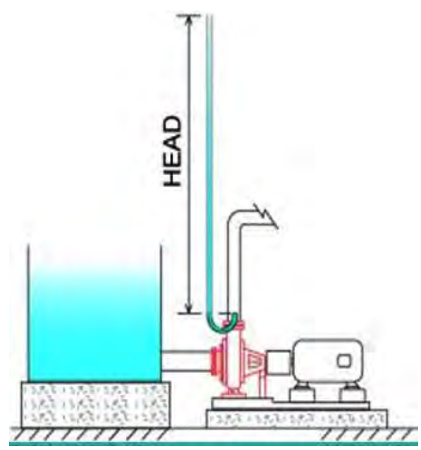
The term "head" is the elevation of free water surface of water above or below a reference datum. For example, if a small, open-ended tube were run vertically upward from a pipe under pressure, the head would be the distance from the center line of the pipe to the free water surface in the vertical tube.



Introduction to Pump Design Basics

Head

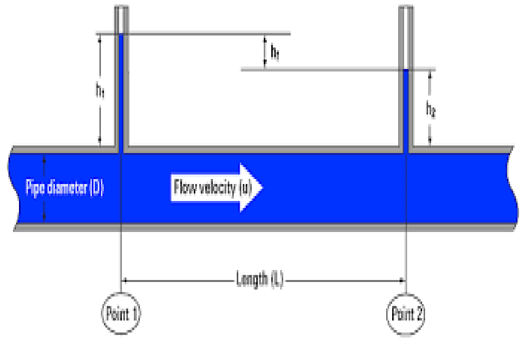
In pumping systems, the head refers to both pumps and pumping systems. The height to which a pump can raise the water is the pump head and it is measured in meters (feet) of flowing water. The head required to overcome the losses in a pipe system at a given flow rate is called the system head.



Introduction to Pump Design Basics

Friction head

The friction head is head of water that must be supplied to overcome the frictional loss caused by the flow of water through the pipe in the piping system. The friction head consists of the sum of the pipe friction head losses in the suction line and the discharge line.



Introduction to Pump Design Basics

Velocity head

The velocity head is the kinetic energy contained in the water being pumped at any point in the system as is given by:

$$\text{Velocityhead} = \frac{V^2}{2g}$$

Introduction to Pump Design Basics

Total Head (TH)

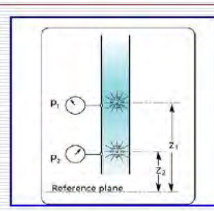
Total Head, is the head against which the pump must work when the water is being pumped. The TH, can be determined by adding total static head, the frictional head loss and pump losses.

TH = TSH+FH

PRESSURE & HEAD RELATIONSHIP

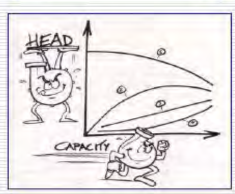
- Pressure (P) = SG x g x Head (H)
- **H = P / (SG x g)**
- **P = H x g x SG**

Where
H = head, in meter
P = pressure, kPa
SG = specific gravity of liquid
g = 9.8 m/sec^2



- **H = P x 2.31 / SG**
- **P = $\frac{H \times SG}{2.31}$**

Where
H = head, in feet
P = pressure, in PSI
SG = specific gravity of liquid
2.31 = conversion factor



The below equations may be used to convert between head and pressure when those measures are in the metric units kPa and m. Gravity is measured in m/s^2.

Conversion from head to pressure:

$$P = \frac{\rho \times g \times h}{1000} = SG \times g \times h$$

Conversion from pressure to head:

$$h = \frac{1000 \times P}{\rho \times g} = \frac{P}{SG \times g}$$

Introduction to Pump Design Basics

Pump Efficiency

Pump performance is measured in terms of the capacity, which the pump can discharge against a given head and at a given efficiency. The pump manufacturer must supply design information on pump performance. Pump efficiency E_p which is the ratio of the useful output power of the pump to the input power to the pump is given by:

Introduction to Pumps Types

Pump Efficiency

$$E_p = \frac{\text{pumpoutput}}{P_i} = \frac{\gamma Q H_t}{P_i} = \frac{\gamma Q H_t}{bhp \times 550}$$

E_p = Pump efficiency, dimensionless

P_i = Power input = Motor output, kW, kN-m/s

γ = Specific weight of liquid, kN/m^3 (lb/ft^3)

Q = Capacity, m^3/s (ft^3/s)

H_t = Total dynamic head, m (ft)

bhp = Brake horsepower

550 = Conversion factor for horsepower to ft-lb/s

Introduction to Pump Design Basics

Centrifugal Pump Nameplate and Designation

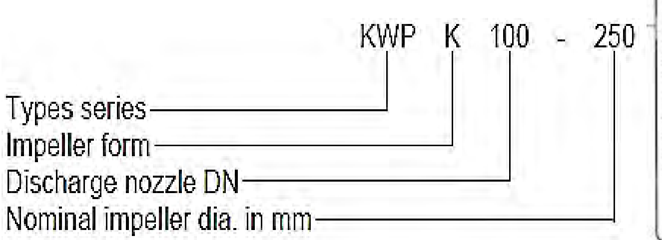
Specification:

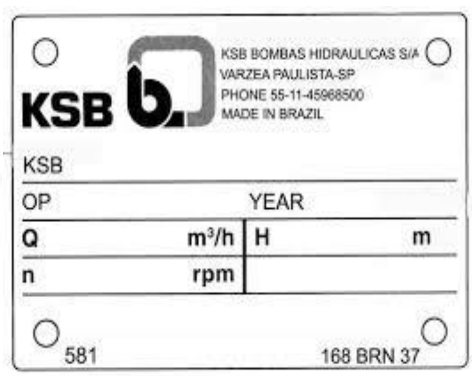
Discharge Diameter: 40--500mm(1.6--20inch)

Flow Capacity: 10--6000m^3/h

Head: 6--80m

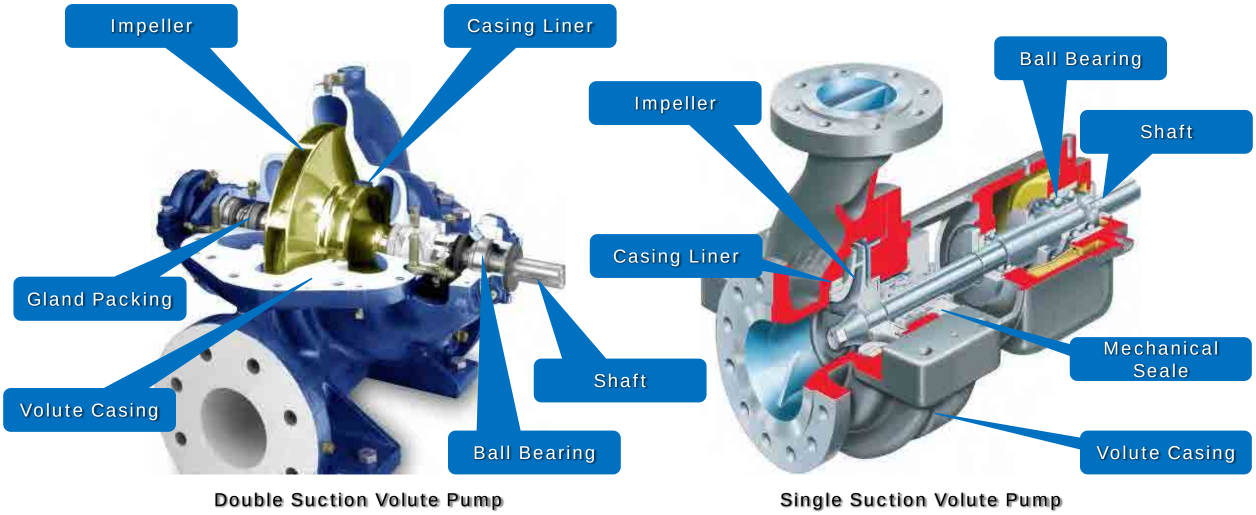
Name Plate and Designation





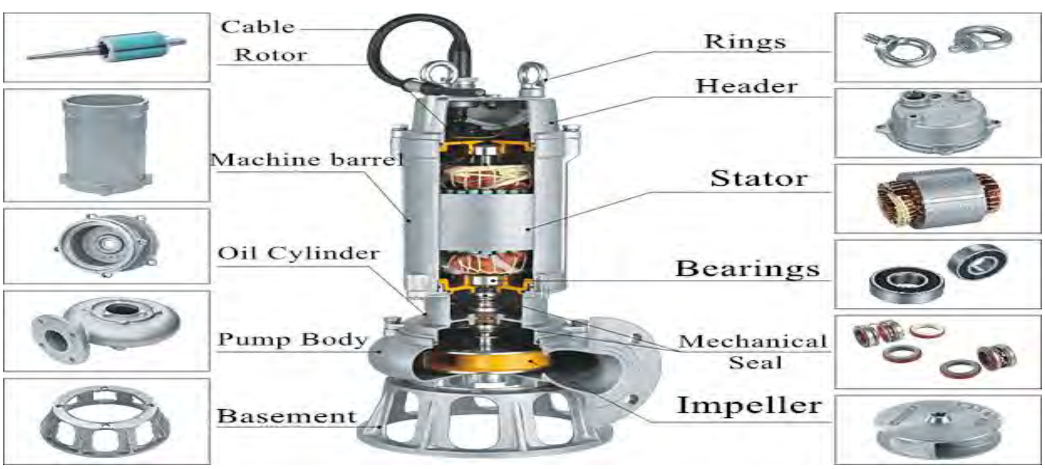
Assembly Parts of Pumps

Centrifugal Pump Structural Parts for Disposal Station



Assembly Parts of Pumps

Submersible Pump Structural Parts for Disposal Station



Pumps Operations

Centrifugal Pump Startup & Operation

- Check and remove debris from sump and pipes
- Check pump should be fully primed.
- Check valves (open)
- Check voltage range for 3-Phase motor.

Pumps Operations

Centrifugal Pump Startup & Operation

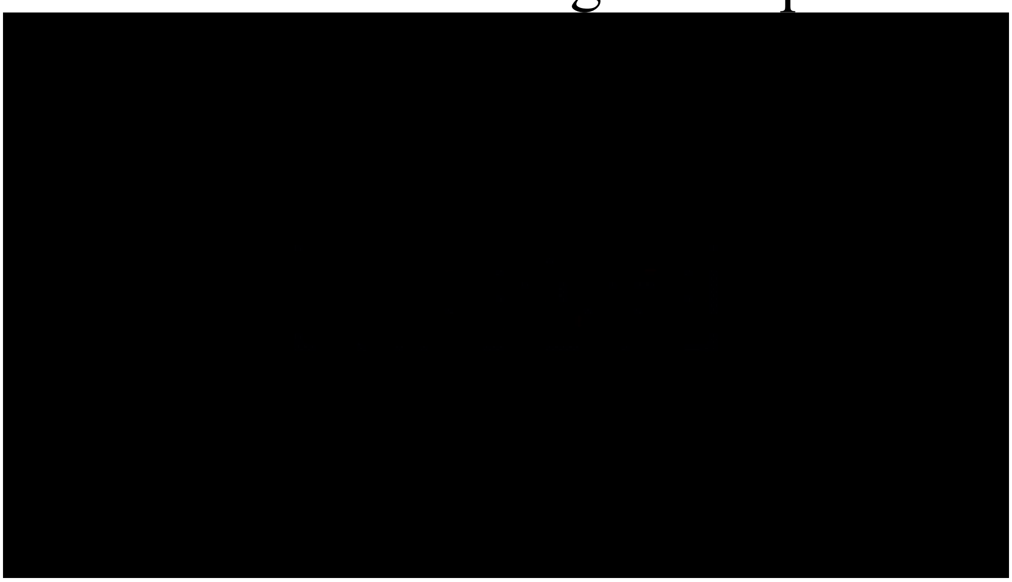
- Check that ammeter reading is less than rated motor current
- After startup check sump level (stable)
- Check for undue vibration and noise.
- After10-15 minutes, check the bearing temperature, stuffing box packing, and leakage through mechanical seal.
- Voltage should be checked every hour.

Preventive Maintenance of Pumps

Preventive Maintenance Centrifugal Pumps

- Adjustment of pump internals
- Replacement of hydraulic components
- Gland Packing Replacement
- Lubrication
- Check bearing temperature and noise.
- Record keeping

Video Centrifugal Pumps



Introduction to Pumps

Vertical Turbine Pump

These pumps are commonly used in groundwater wells. These pumps are driven by a shaft rotated by a motor on the surface

Introduction to Pumps Types

Vertical Turbine Pump

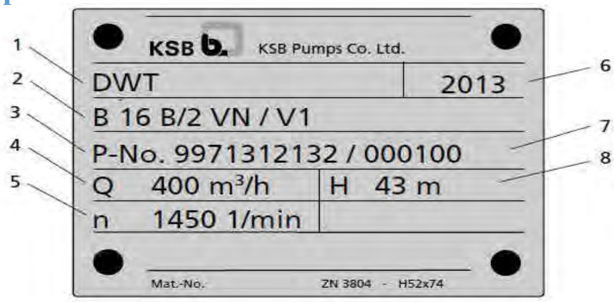
DesignationExample: B 16 B/2 VN / V1

Code	Description
B	Type Series
16	Well diameter in inches (16 = 16")
B	Hydraulic system (B impeller)
2	Number of stage of hydraulic system
VN	Type of installation (VN=Discharge nozzle above floor)
V1	Type of derive (V1= direct derive by vertical electric motor)

Introduction to Pumps Types

Vertical Turbine Pump

Name plate with description



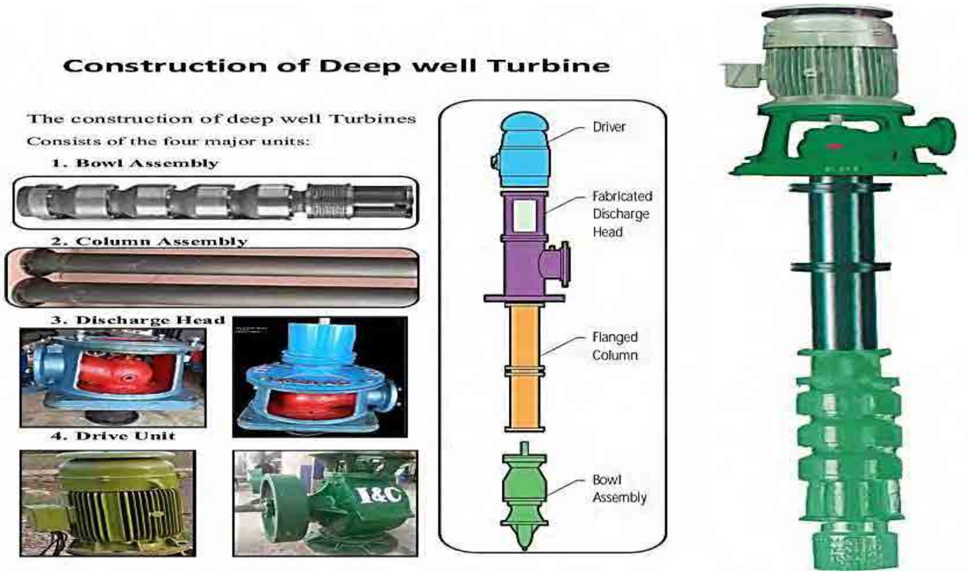
1	Pump type	2	Designation of the pump set
3	Order number	4	Flow rate
5	Speed	6	Year of supply
7	Order item number	8	Head

Introduction to Pumps Types

Submersible Pump

A type of pump in which the motor and pump both are in the ground water reservoir. Motor is water proof and electricity is provided to the motor by a water proof cable.

Assembly Parts of Pumps



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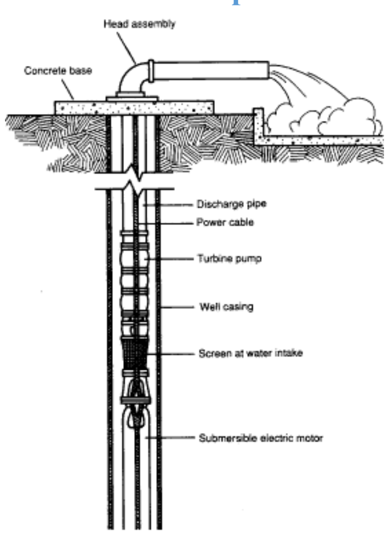
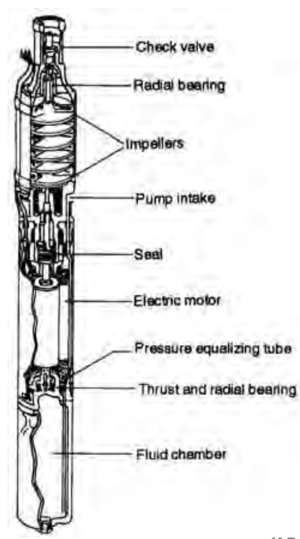
Assembly Parts of Pumps

Structural Parts of Submersible Pump for Tube well





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Comparison of Vertical pump and Submersible pump

	Vertical shaft centrifugal pump (Tube well)	Submersible motor pump (tube well)
Picture		
Bore size	Cover a wide range	Max bore: approx. 200 mm
Flow capacity	Cover a wide range	Small
Head	Cover a wide range	Cover a wide range
Efficiency	Small bore: almost equal with submersible motor pump Big bore: Max eff. approx.90%	Maximum: approx. 80%
Installation	complex	Easy
Maintenance	complex	Easy
Cost	Expensive than Submersible motor pump	Cheaper than Vertical shaft pump
Vibration/Noise	Need attention	No need to pay attention compare to Vertical pump
Leakage	Need attention	No need to pay attention compare to Vertical pump

Pumps Operations

Vertical Turbine Pump Startup & Operation

- Check pump lubricate water tank is filled and lubricate.
- Check valves (open).
- Check voltage range for 3-Phase motor.
- Check Open the air vent in discharge/delivery pipe (not standard, if air release valve is working)
- Check for proper rotation
- Check steady water stream is let out through air vent, close the air vent.
- Check that ammeter reading is less than rated motor current.

Pumps Operations

Vertical Turbine Pump Startup & Operation

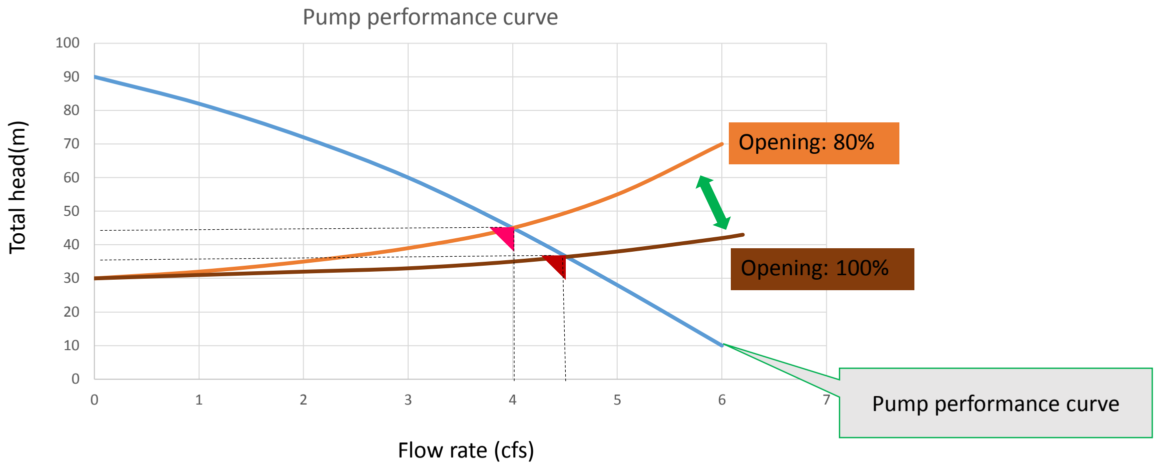
- After startup check pressure for operating point.
- Check for undue vibration and noise.
- After10-15 minutes, check the bearing temperature, stuffing box packing, and leakage through mechanical seal.
- Voltage should be checked every hour.

Pumps Operations

Submersible Pump Startup & Operation

- Check water level in bore hole.
- Check valves (open).
- Check voltage range for 3-Phase motor.
- Check that ammeter reading is less than rated motor current.
- After startup check pressure for operating point.
- Check for undue vibration and noise.
- Voltage should be checked every hour.

Pumps Performance



Preventive Maintenance of Pumps

Preventive Maintenance Vertical Turbine Pumps

- Lubricate the bearings on pumps supplied with lubrication points.
- Inspect the packing or mechanical seal
- Check for unusual noise, vibration, and bearing temperatures.
- Check the pump and piping for leaks.
- Check the source of vibrations and acceptable levels.
- Record keeping

Preventive Maintenance of Pumps

Preventive Maintenance Pumps

Stuffing-box box leaks

✓ **Normal leaks**

With the pump in operation, there should be some leaking at the stuffing box packing. The correct leak rate is a rate which keeps the shaft and stuffing box cool. Check the temperature of the leaked fluid as well as the discharge head.

✓ **Decreased leaks**

If the pump runs hot and the leaks begin to decrease, stop the pump and allow it to cool down. Loosen the packing gland in order to allow the packing to resume leaking. After pump has cooled, restart pump and run it for 15 minutes. Then check the leaks. If the leak exceeds 20 drops per min or six liters per hour adjust or change gland pack (as per KSB service department).

Regular Submersible Pump (Motor) Inspections

Frequency	Inspection Items	Remarks
Daily	1. Check for excessive vibration and strange sounds. 2. Check working order. 3. Check electric current values.	・Confirm that there are no sudden changes in current or pressure. ・Measure and record values regularly.
Monthly	1. Measure Insulation resistance. 2. Measure continuity.	・Check insulation resistance lower limits.
Annual	1. Check protective equipment (thermal protectors, flood detectors etc.) status. 2. Inspect appearance.	・Confirm their continuity. ・Pull the pump and check for any damaged parts
Every 2-3 Years	1. Overhaul and service unit.	・Replace any worn parts.(mechanical seals, bearings) ・Confirm any repair any wear, Deformities, corrosion, or faulty parts.

Notes: Inspect the unit everyday if it is used 2,000 hours or more consecutively in one year. The frequency of overhauls varies according to the amount of use.

Troubleshooting

Trouble shooting Pumps

1. Troubles are of 3 types: mechanical, hydraulic and motor related
   - ✓ Mechanical troubles: Breakage of coupling or shaft
   - ✓ Hydraulic troubles: Failure to deliver water, reduction in discharge and over loading.
   - ✓ Motor troubles: If conditions change, adjustments in pump speed and/or impeller diameters may require changes.
2. Flow rate increases – check if system head decreased, is motor tripping on overloading?

.

Troubleshooting

Trouble shooting Pump

3. Flow rate decreased – check if system head is increased, obstruction in pipe, worn impeller, check pump speed is as specified.
4. Vibrations – check obstruction in suction, cavitation, impeller with solid particle logged in vane, system alignment (shaft, coupling etc.), tightening of installation bolts
5. Seal leakage – while running or at shut down? – check suction conditions, wear in parts, pump speed, changes in system.

Troubleshooting

Trouble shooting Centrifugal Pump

No liquid delivered

- Lack of prime
- Speed of electric motor or engine too low
- Discharge head too high
- Suction lift too high
- Impeller plugged
- Vapor lock in suction line

Troubleshooting

Trouble shooting Centrifugal Pump

Not enough water discharge

- Air leaks
- Worn wearing rings
- Damaged impeller
- Defective foot valve
- Worn gaskets

Troubleshooting

Trouble shooting Centrifugal Pump

Overloading of Motor / Engine

- Low discharge head
- Packing too tight
- Bent shaft
- Distorted casing
- Pump speed too high

Troubleshooting

Trouble shooting Vertical Turbine Pump

1. If conditions change, adjustments in pump speed and/or impeller diameters may require changes.
2. Flow rate increases – check if system head decreased, is motor tripping on overload?
3. Flow rate decreased – check if system head is increased, obstruction in pipe, worn impeller, check pump speed is as specified.

Troubleshooting

Trouble shooting Vertical Turbine Pump

4. Vibrations – check obstruction in suction, impeller with solid particle logged in vane.
5. There is excessive leakage from the stuffing box – The packing is defective. Replace any packing that is worn or damaged

Troubleshooting

Trouble shooting Submersible Pump

1. If conditions change, adjustments in pump speed and/or impeller diameters may require changes.
2. Flow rate increases – check if system head decreased, is motor tripping on overload?
3. Flow rate decreased – check if system head is increased, obstruction in pipe, worn impeller, check pump speed is as specified.

Troubleshooting

Trouble shooting Submersible Pump

4. Vibrations – check obstruction in suction, impeller with solid particle clogged in vane.
5. Sand in well discharge and/or excessive pump impeller wear

Possible problem	**Solution**
Damaged well screen or gravel envelope	In some cases a drilling contractor may be able to replace or repair the screen or gravel envelope.
Flow is drawing sand into the well	Throttle back the flow rate to reduce the problem. A drilling contractor may also need to redevelop the bore to flush out the sand around the bore screen (or take other measures as appropriate).

Troubleshooting

Trouble shooting Submersible Pump

Possible problem	**Solution**
Rapid stop/start pumping agitating the bore and not flushing out the sand	Look at the pump controls. Install storage or a variable speed drive (not always appropriate).

Motor Size Calculation

Shaft Power Calculation

Pump efficiency (η):

Pump efficiency is different depending on the operating point, pump type, and capacity etc. Pump is operated high efficiency point, energy and cost consumption can be suppressed. Therefore, pump user should select highest pump efficiency point at the pump operation point as well as possible.

Motor Size Calculation

Liquid power (L_w):

The effective energy given to a liquid by a pump in a unit of time, expressed by the following equation.

$$L_w = \rho g Q H / 1{,}000 \text{ (kW)}$$

Where L_w : Liquid power $[kW]$

ρ : Liquid density $[kg/m^3]$

Note: In case of tube wells, the density is almost 1,000 kg/m^3

g : Gravity accelaration $[m/s^2]$

Note: Gravity acceleration on the Earth is almost 9.8 m/s^2

Q : Capacity $[m^3/s]$

H : Total head [m]

Motor Size Calculation

Shaft power (L):

The necessary power that a pump transports liquid to required destination (height, distance) is called SHAFT POWER and expressed by the following equation. Shaft power is used for motor selection.

$$L = L_w / \eta \text{ (kW)}$$

$$L = \rho g Q H / \eta \text{ (kW)}$$

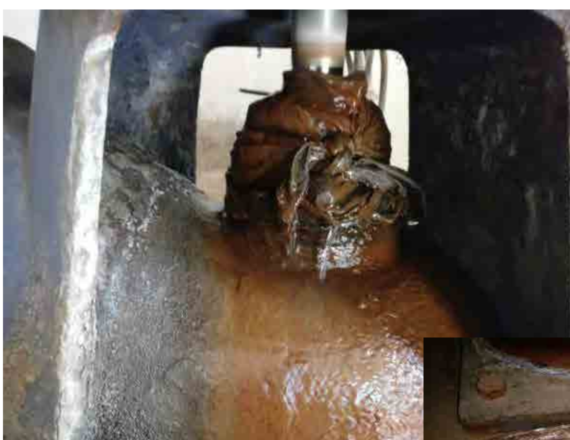
$$L = 0.75 \times \rho g Q H / \eta \text{ (PS)}$$

Power output determination

Driver power output is decided by calculating the shaft power and by considering shaft power allowance rate, expressed by the following equation.

$$P = L(1 + \alpha)$$

Suggested Improvement



Suggested Improvement

Suggested Improvements

Suggested Improvements

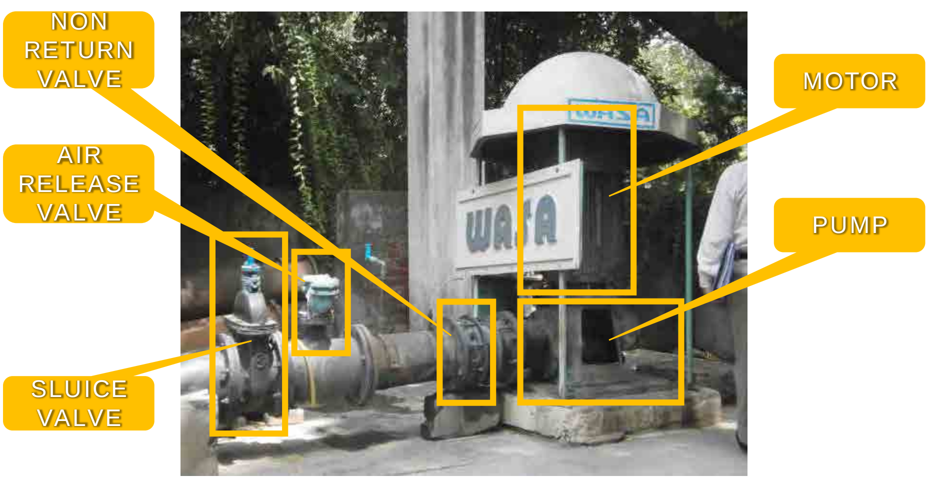
Suggested Improvements

Suggested Improvements

Current Conditions

Suggested Improvement

Current Conditions



Suggested Improvement

Suggested Improvement

Things to remember !!!

- ✓ Follow SOPs

O & M of Mechanical Equipment
WSD 5231

Module 1

Valves

WSD 5231, Mod 1

2

Icebreaker and Class Introduction

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

Agenda

- ✓ Ice Breaker and class introduction
- ✓ Resources and handouts
- ✓ Introduction and selection of valve
- ✓ Assembly parts of valves

Agenda

- ✓ Valve operations
- ✓ Preventive maintenance of valves
- ✓ Troubleshooting of valves

Icebreaker and Class Introduction

Now it is your turn…

- Degree and backgrounds?
- Share your work experience relative to Valves?

Resources and Handouts

- MANUAL OF WATER SUPPLY PRACTICES—M44, Second Edition Distribution Valves: Selection, Installation, Field Testing, and Maintenance AWWA(2006)
- Pumps and Pumping (Arasmith, S. 2006) ACR Publications, London

Resources and Handouts

- Participant lecture notes, Module 1
- Class presentations, Module 1
- O and M of Valves Manual
- JICA, Manual on sewerage and sewage treatment, Part B: Operation and Maintenance, Ministry of Urban Development, New Delhi

Introduction and selection of valves

Valve

A valve is a device that regulates, directs or controls the flow of a fluid by opening, closing, or partially obstructing various passageways.

Valve Functions

- ✓ Stopping and starting fluid flow.
- ✓ Varying (throttling) the amount of fluid flow.
- ✓ Controlling the direction of fluid flow.
- ✓ Regulating downstream system or process pressure.
- ✓ Relieving component or piping pressure.

Introduction and selection of valves

Classification of Valves

The following are some of the commonly used valve classifications, based on mechanical motion:

Linear Motion Valves.

The valves in which the closure member, as in gate or sluice, moves in a straight line to allow, stop, or throttle the flow.

Introduction and selection of valves

Classification of Valves

Rotary Motion Valves.

When the valve-closure member travels along an angular or circular path, as in butterfly valves.

Quarter Turn Valves.

Some rotary motion valves require approximately a quarter turn, 0 through 90°, motion of the stem to go to fully open from a fully closed position or vice versa.

Introduction and selection of valves

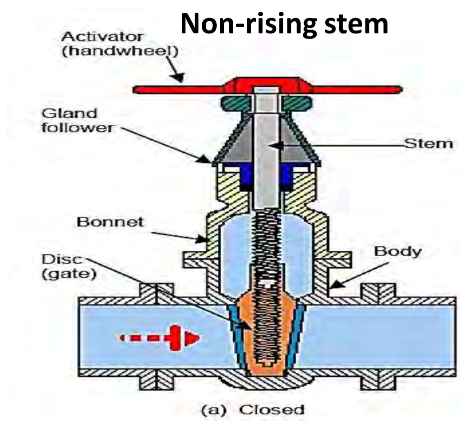
Classification of valves based on motion

Valve types	Linear motion	Rotary motion	Quarter turn
Gate Valve	x		
Air release valve	x		
Butterfly valve		x	x
Non-return valve		x	x
Flap valve		x	

Assembly parts of valves

Basic Parts of the valve

- Body
- Bonnet
- Trim (internal elements)
- Actuator (Handwheel)
- Packing



Assembly parts of valves

Basic Parts of the valve

Bonnet

The cover for the opening in the valve body joint.

Bonnets Features

- Bonnet is the second principal pressure boundary of a valve.
- It is cast or forged of the same material as the body and is connected to the body by a threaded, bolted, or welded

Bolted Bonnet

Assembly parts of valves

Basic Parts of the valve

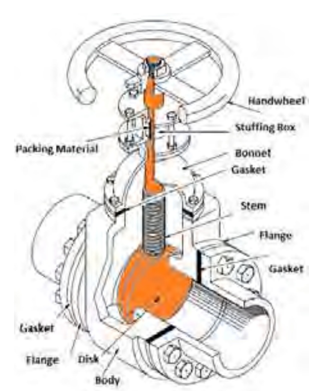
Body

It is called the shell, is the primary pressure boundary of a valve. It serves as the principal element of a valve assembly because it is the framework that holds everything together.

Introduction and selection of valves

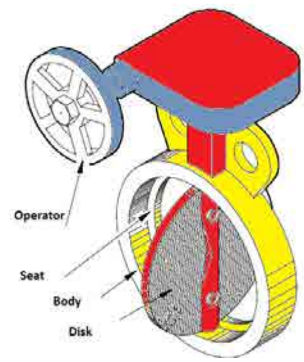
Methods of controlling flow through a valve.

1. Slide a flat, cylindrical, or spherical surface across the orifice.



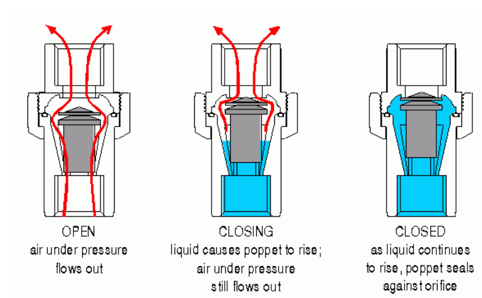
Gate valve

2. Rotate a disc or ellipse about a shaft extending across the diameter of an orifice.



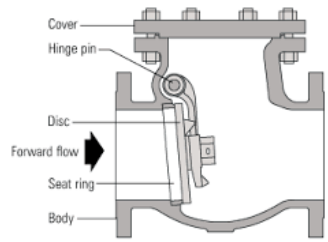
Butterfly valve

3. Ball linearly moves upwards to close of an orifice.



Air release valve

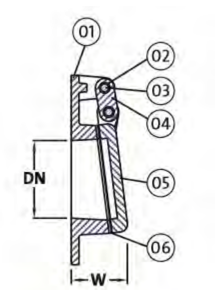
4. Non return valve rotates a disc to stop the backflow of the fluid



Non return valve

5. Flap valve rotates a cover disc to hinder air suction and backflow of the fluid. Installed at the open end of discharge pipe.

Item	Description
01	Body
02	Bush
03	Hinge pin
04	Links
05	Flap
06	Seating face



Flap valve

Valve Type and Material Selection

Selection Consideration

1. **Pressure**

2. **Temperature**

3. **Type of fluid**
   - A. Water
   - B. Wastewater (corrosive)
   - C. Water with sand (abrasive)

4. **Flow Considerations**
   - A. On-off or Throttling
   - B. To prevent backflow
   - C. Concern for pressure drop
   - D. Velocity
   - E. Flow resistance

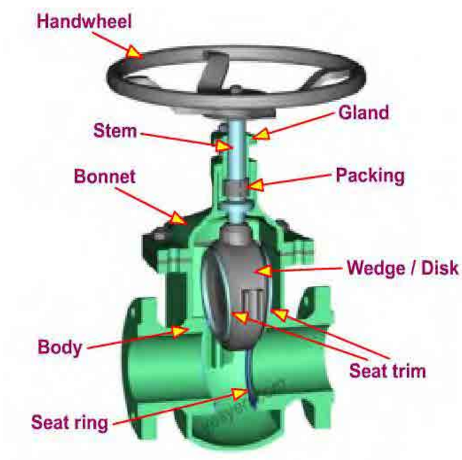
5. **Operating conditions**
   - A. Frequency of operation.
   - B. Accessibility.
   - C. Overall space/size available.
   - D. Manual or automated control.
   - E. Need for bubble-tight shut-off.
   - F. Concerns about body joint leaks.
   - G. Fire safe design.
   - H. Speed of closure.

Introduction and selection of valves

Valve Types

Gate Valves

Flow is controlled by raising or lowering the disk. Gate valves are not usually used to regulate flow because the valving element can be damaged when in the partially open position. Similarly, they also limit the pressure drop across the valve when fully open.



Introduction and selection of valves

Valve Types

Gate Valves

Advantages

- Gate valves opens or closes slowly, which prevents fluid hammer and
- Subsequent damage to the piping system.
- They need long operation time since setting the valve to the fully open or closed position requires the handle to be turned many times.
- Good choice for on-off service.
- Full flow, low pressure drop.
- Bidirectional.

Introduction and selection of valves

Valve Types

Gate Valves

Disadvantages

It is not suitable for throttling applications.

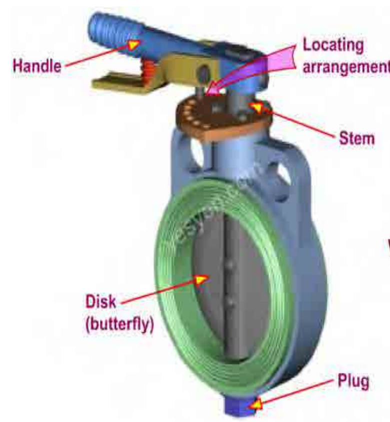
- It is prone to vibration in the partially open state.
- It is more subject to seat and disk wear.
- Repairs, such as lapping and grinding, are generally more difficult to accomplish.

Introduction and selection of valves

Valve Types

Butterfly Valves

Butterfly valves are rotary motion valve that is used to stop, regulate, and start fluid flow.



Introduction and selection of valves

Valve Types

Butterfly Valves

Advantages

- They are suitable for large valve applications.
- Compact, lightweight design.
- The maintenance costs are usually low.
- Pressure drop across a butterfly valve is small.
- Used with chemical or corrosive media.

Introduction and selection of valves

Valve Types

Butterfly Valves

Disadvantages

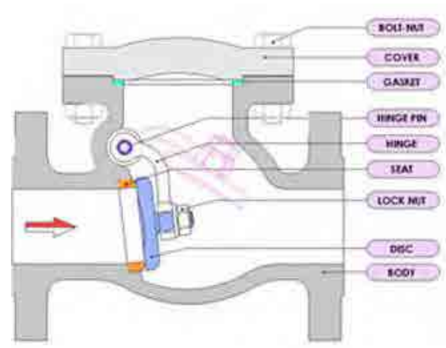
- Difficult to clean
- Throttling limited to low differential pressure
- Potential for cavitation and choke
- Unguided disc movement is affected by flow turbulence

Introduction and selection of valves

Valve Types

Check or Non return valve

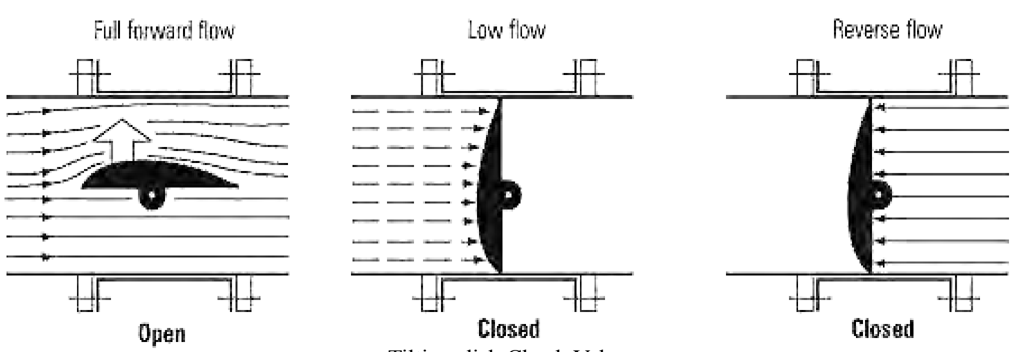
Check valves are designed to prevent the reversal of flow in a piping system. These valves are activated by the flowing material in the pipeline. The pressure of the fluid passing through the system opens the valve, while any reversal of flow will close the valve.



Introduction and selection of valves

Valve Types

Check or Non return valve



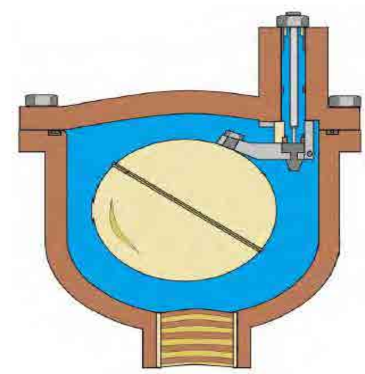
Tilting-disk Check Valve

Introduction and selection of valves

Valve Types

Air Release Valves

An air release valve is generally a self-actuated valve that automatically vents small pockets of air that accumulate at the high point in a water distribution system when the system is operating under pressure.



Introduction and selection of valves

Valve Types

Air Release Valves

Advantages

- Air release valves protect the pipeline system and maintain its efficiency.
- These valves are perfect for quickly venting large volumes of air during filling or startup.
- This is important because some pipe materials can collapse under negative pressure.

Introduction and selection of valves

Valve Types

Air Release Valves

Advantages

- Once an air release valve is installed, it constantly operates automatically.

Disadvantages

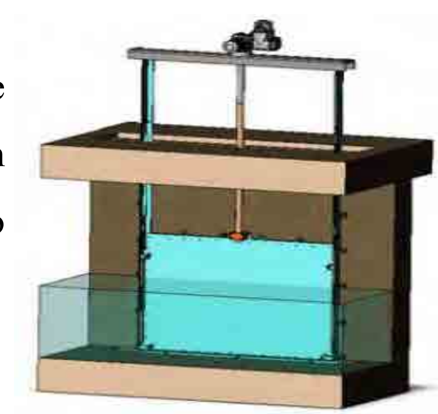
- If a pipeline is filled or emptied too quickly, an air release valve does not always keep up with the air flow demands.
- You must size the valve correctly for your application.

Introduction and selection of valves

Valve Types

Penstock Valve

A penstock is a sluice or gate or intake structure that controls water flow, or an enclosed pipe that delivers water to hydro turbines and sewerage systems



Valves operations

Guidelines to close a valve

Crews should follow the following guidelines to close a valve properly:

1. Begin with a steady amount of torque in the direction necessary to close the valve, moving through 5 to 10 rotations.
2. Reverse for two or three rotations.
3. Reverse again and rotate 5 to 10 more turns in the closing direction.
4. Repeat this procedure until full closure is attained.

Valves operations

Guidelines to close a valve

5. Once the valve is fully closed, it should be opened a few turns so that high- velocity water flowing under the gates can move the remainder of the sediment downstream with more force and clear the bottom part of the valve body for seating.
6. Fully close the valve again.

Causes of Debris and Sediment valve

- If cautious approach is not apply than debris and sediment often build up on the gates, stem, and slides.
- If this material is compacted while the valve is being closed, the torque required to close the valve continues to build as the material is loaded.
- If the procedure previously described is used, the stem and other parts are "scrubbed" by the series of back-and-forth motions, and water in the system can flush the debris that has broken loose away from the stem gate and slides or guides.

Preventive maintenance of valves

Valve Maintenance Procedures

- A valve that has not been operated for a number of years needs to be closed by using a series of up and down motions.
- Crews attempting to close a difficult valve should never use a T-handle and extension to force the valve closed.
- Such over torque to obtain a positive shutoff can cause damage to the valve.

Preventive maintenance of valves

Valve Maintenance Procedures

- Torque- limiting devices are available.
- Gland pack leakage check and replacement
- Proper lubrication
- If possible use SS bolts

O & M of Mechanical Equipment
WSD 5231

Chlorination and Filtration System

Module 2

Agenda

- ✓ Ice Breaker and Class Introduction
- ✓ Resources and handouts
- ✓ Introduction to chlorination and filtration systems and assembly parts.

Agenda

- ✓ Importance of Chlorination and Filtration System in WASA operations
- ✓ Dosage calculation in chlorination systems and WHO guidelines.
- ✓ Operation of chlorination and filtration system.
- ✓ Preventive maintenance

Icebreaker and Class Introduction

- What do we cover in this module?
- What to expect in this module?
- Goal and objectives of this module?

Icebreaker and Class Introduction

Now it is your turn…

- Degree and backgrounds?
- Share your work experience relative to Chlorination and Filtration System?

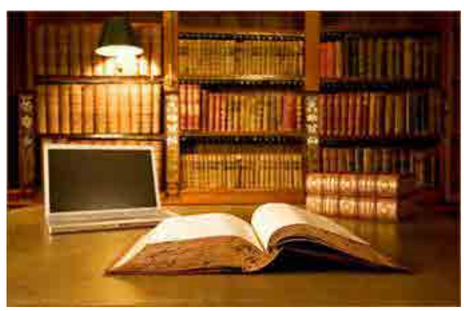
Icebreaker and Class Introduction

Now it is your turn…

- Any prior experience on Chlorination and Filtration System?
- Why interested in this module?
- What best skills do you bring to the class?

Resources and Handouts

- Owner's Manual, KSB Filtration system
- Pumps and Pumping (Arasmith, S. 2006) ACR Publications, London
- O and M of Chlorinator feed pump Manual
- Participant lecture notes, Module 4
- Class presentations, Module 4



Introduction to Chlorination and Filtration Systems

Chlorine Disinfection (Chlorination)

Chlorination is the addition of chlorine to water to make it safe for human consumption. Chlorine (and its compounds) is the most widely used disinfectant for water systems because of its effectiveness, economy and ease of application.

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

- Chlorination has the advantage of **oxidizing bacteria and virus** even after the point of application due to its residual action.
- If any bacteria introduced to the system after the point of chlorination can still be eliminated by the **residual chlorine** in the water.

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

There are two type of chlorinator which is used in WASA

1. Hypo Chlorinator

2. Drip Type Chlorinator

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

1. Hypo-chlorinator

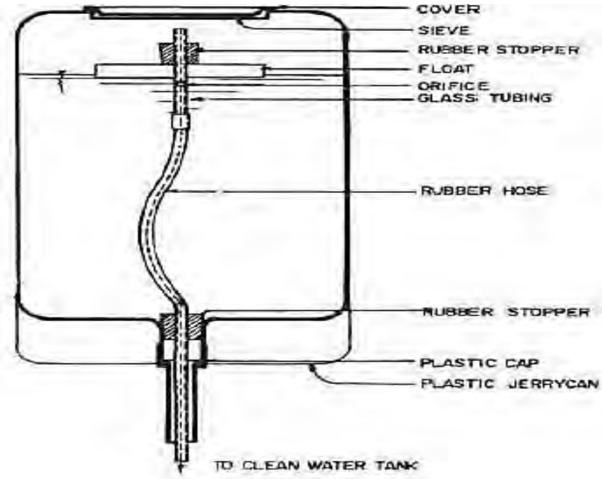
The hypo-chlorinator is a pump used to add hypochlorite solutions to water at a manually adjustable feeding rate. Pump draws the hypochlorite solution from a container and transfers it into the water for treatment.

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

1. Drip-type chlorinator

A drip-type chlorinator can be used for disinfecting small reservoirs, wells and cisterns.



Introduction to Chlorination

Chlorine Disinfection (Chlorination)

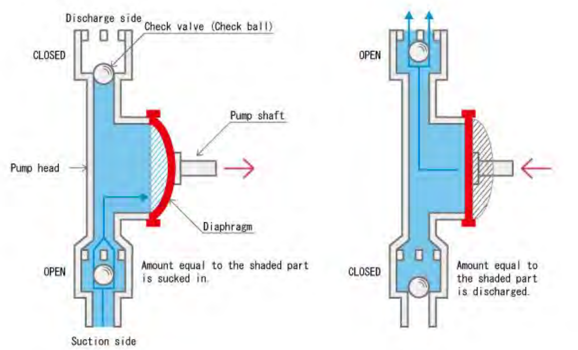
Diaphragm pump in chlorinator

A diaphragm pump (also known as a Membrane Pump) is a positive displacement pump that uses a combination of the reciprocating action of a rubber, thermoplastic or Teflon diaphragm and suitable valves.

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

Flow Diagram of Diaphragm Pump



Introduction to Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump characteristics:

- Have good suction lift characteristics, some are low pressure pumps with low flow rates; others are capable of higher flow rates, dependent on the effective working diameter of the diaphragm and its stroke length.

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

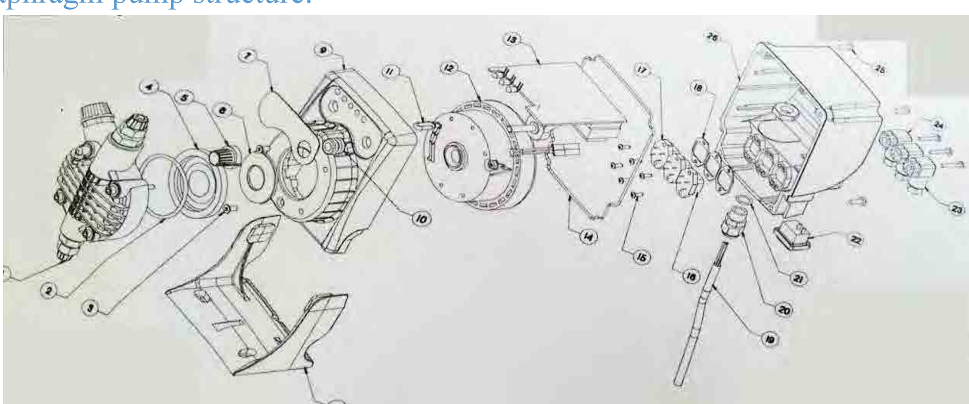
Diaphragm pump properties:

- Suitable for discharge pressure.
- Have good dry running characteristics.
- Also used to make air pumps for the filters on small fish tanks.
- Have good self priming capabilities.
- Can handle highly viscous liquids.

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump structure:



Structure of Diaphragm Pump

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Names of Parts:

S.No's	Names of Parts	S.No's	Names of Parts	S.No's	Names of Parts
1	Pump Head	10	Potentiometer Gasket	19	Power Cable
2	Pump Head O-ring	11	Thermostat	20	Cable Clamp
3	Electromagnet screw	12	Electromagnet	21	Cable Clamp O-Ring
4	PTFE Diaphragm	13	PC Board	22	Switch
5	Pulse Adjusting Knob	14	Back Cover Gasket	23	Output Connector
6	Flange	15	Connector Screw	24	Power Supply
7	Control Panel Serigraphy Film	16	Output Connector(Male)	25	Back Cover Screw
8	Bracket	17	Power Supply Connector(Male)	26	Back Cover
9	Casing	18	Connector Gasket		

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Main Components:

Main Component

Control Unit

Pump Head O-ring

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Main Components:

PTFE Diaphragm

Main component

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Main Components:

Thermostat/Electromagnet

Head,Drain,suction,Discharge points

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Main Components:

PTFE (polytetrafluorethylene)

It is a thermoplastic polymer with superior chemical resistance. The PTFE pump will handle even the most aggressive acids, for instance concentrated nitric acid. Maximum liquid temperature is up to 100°C.

PTFE

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Main Components:

Non Return Valve

A valve which can allow the water to flow only in one direction its used in suction and discharge side of the diaphragm pump. In diaphragm pump its made up of rubber material its just open when dosing the chlorine and then close.

Non Return Valve

Assembly components of Chlorination

Chlorination system used in WASA tube well

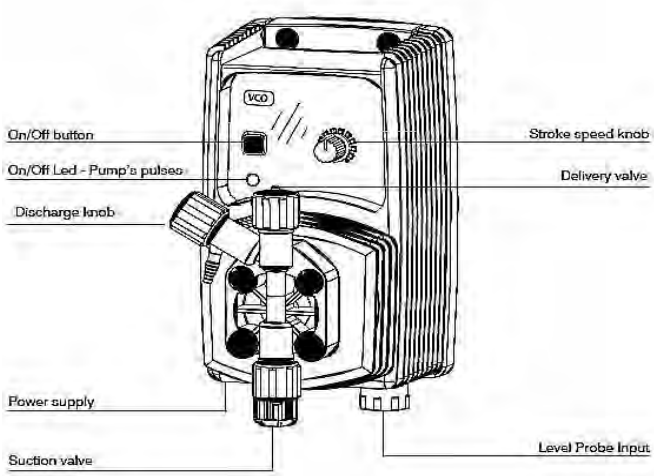
WASA use different types feed pumps for chlorine supply, most common are

a) EMEC V Pump

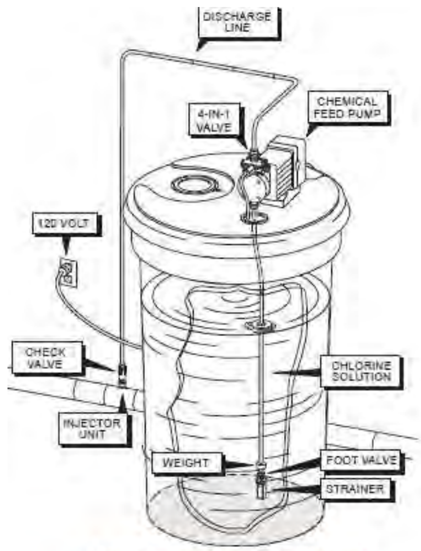
b) CHEM TECH Pump

Assembly components of Chlorination

a) EMEC V Pump Assembly Components



Components of tube well chlorination system



Typical hypochlorination feed equipment

SOPs for Chlorinator

- Check the sodium hypochlorite level in the tank
- Connect the pipe connection with drain to remove all the water or any chemical which is inside the pump and pipe.
- Set the knob for discharge or pulse stroke as per sodium hypochlorite percent discharge requirement (i.e. WASA Lahore uses 18 %)
- Turn on the diaphragm pump.
- Check if there is need to adjust the chlorinator discharge based upon actual tube well water flow rate

WASA related info

- In WASA's system chlorine inject directly at tube well system
- The Direct injection of chlorine to tube well pump may cause damage to the metal parts of tube well

  (use of drip type)

Quantity of Chlorine Used

- Sodium Hypo-chlorite solution is used.
- WASA Lahore 1ppm.
- WASA Gujranwala 0.6-0.8 ppm.
- WASA Rawalpindi 1-2ppm.
- WASA Multan 0.5ppm.
- WASA Faisalabad Ground Water 2ppm and for surface water 1.25ppm But pressurized chlorine gas used.

Dosing of Chlorine in WASA system

Periodic Maintenance for Chlorinator

Check once a month:

- ✓ Pump discharge knob position
- ✓ Strainer cleaning
- ✓ Suction and discharge pipe clogging
- ✓ Drain clogging

Check once a year:

- ✓ Non-return valve (both suction and discharge) clogging or breakage, condition of diaphragm (you will need to open the pump)
- ✓ Verify pump discharge rate by use of a metered collection tube

Troubleshooting for Chlorinator

The Metering Pump gives Pulses but the additive is not injected

a.

Check Valve

- Dismount the suction and discharge valves, clean them and replace.
- Should the valves be swollen or have cracks, replace them with standard valves by the manufacturer

Troubleshooting for Chlorinator

The Metering Pump gives Pulses but the additive is not injected

b.

Check Clogging of the filter

Check clogging of the filter.

Attention:

When removing the metering pump from the plant, be careful as there might be some residual additive in the discharge hose.

Check the Clogging in filter

Troubleshooting for Chlorinator

Electrical Faults for Chlorinator EMEC V Pump

1. All LEDs off, The Pump does not pulse

Check power supply(Socket, plug, power switch on). If the pump does not work contact manufacturer customer service, dealer or distributor.

2. Green LED(Power) On, Red LED(Pulse) off,

The pump does not pulse. Check flow rate adjustment knob(4),turning it to max flow rate. If the pump does not work contact manufacturer customer service, dealer or distributor.

Pulse Knob, Electrical Connections

Troubleshooting for Chlorinator

Electrical Faults for Chlorinator EMEC V Pump

3. Pump Pulses are not constant

Check that supply voltage is within +/- 10% of rated voltage.

4. The Dosing pump gives only one pulse

Disconnect the equipment and contact manufacturer customer service, Dealer or distributor.

Water Quality WHO guidelines.

Sr. NO.	*CHEMICAL & PHYSICAL TEST*	*GUIDELINE*	*RESULT*
1	Temperature.	-----------------	
2	pH.	6.5----------8.5	
3	Adour.	Unobjectionable	
4	Colour.	5---------50 TCU	
5	Taste.	Unobjectionable	
6	Turbidity	0--------5 NTU	
7	Clay/Sand/Rust.	Absent.	
8	Conductivity. µs/cm	------------------	
9	Total Dissolved Solid. mg/L	1000	

Sr. NO.	*CHEMICAL & PHYSICAL TEST*	*GUIDELINE*	*RESULT*
10	Total Hardness. mg/L	150-------500	
11	Calcium. mg/L	75--------200	
12	Magnesium. mg/L	30---------150	
13	Alkalinity. mg/L	-	
14	Chloride. mg/L	250	
15	Nitrites.	-	
16	Nitrates. mg/L	0-------------45	
17	Carbonates. mg/L	-	
18	Bicarbonates. mg/L	-	
19	Fluorides. mg/L	0------1.5	

WASA Chlorination practice

Presently WASA use Chlorination by outsourcing Sodium hypochlorite solution

- **No SOP for chlorination is available with WASA**
- **19.9 – 19.5 mg/*l* Sodium Hypochlorite Solution is available**
- **Main store delivers sealed container to WASA tube wells on demand**
- **Chlorine evaporates only in summer resulting drop of concentration by 0.25 mg/*l***
- **In winter, no evaporation of chlorine occurs**

WASA Chlorination practice

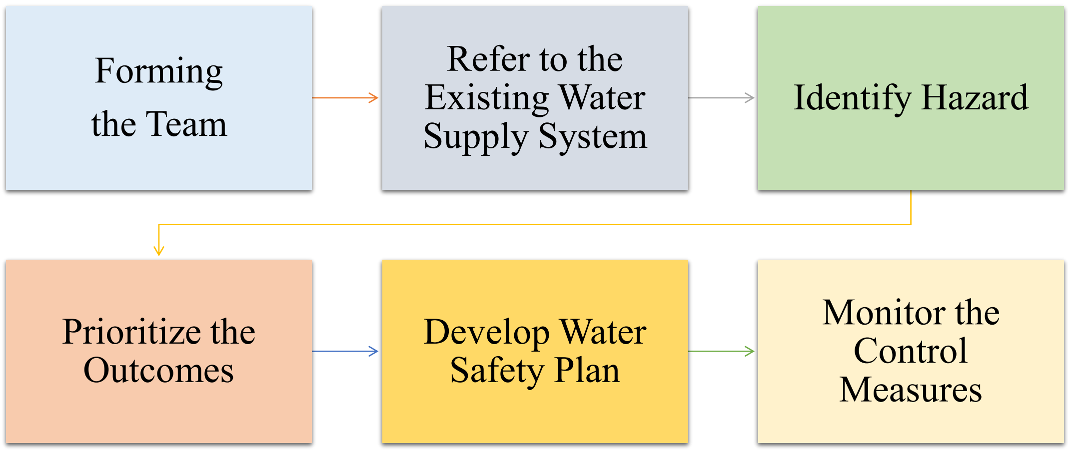
- Chlorine concentration could be preserved by keeping the cap close tight
- Assessment of residual Chlorine is conducted by Chlorine Kit
- Residual chlorine is assessed on
  a. Routine basis
  b. Complaint basis
  c. Upon Report of Unfit Water sample
- Residual Chlorine concentration vary from 0.1 – 0.5 mg/*l*

Water Safety Plan

Components of Water safety plan

- Health Based Targets
- System Assessment
- Operational Monitoring of Control Measures
- Management Plan
- Surveillance System

Implementation of Water Safety plan based on ISO 18001



Forming the Team

- Team must have operational experience
- Major role of team is to identify possible hazards linked with water quality in water distribution system and application of control measures

Implementation of Water Safety plan based on ISO 18001

Ground Water Abstraction → Chlorination → Distribution System → Consumers

System Flow Diagram based on Groundwater Source

System Assessment

- ✓ Assessment of existing water supply system
- ✓ Developing system flow diagrams from source up to consumers

Hazard Identification & Control Measures

Sr. No.	Hazard Type	Problems with associated hazard	Control Measures	Key Responsibility
	Water Source			
1	Microbial and chemical Hazards	• Deterioration of water quality due to Natural Factors (seasonal variations, soil aggressiveness) and wastewater discharges	• Good practices of source protection through installation of filtration plant • Implementation of Industrial Effluent Standards and Volume Controls	SDO, Supervisor, Operator

Hazard Identification & Control Measures

Sr. No.	Hazard Type	Problems with associated hazard	Control Measures	Key Responsibility
	Transmission Mains			
1	Microbial Hazard	• Poor water quality due to source contamination • Deposits of sediments • Disinfection failure due to high loads of organic contents in water from source	• Stop the flow of water by closing valves of problem area • Provide a temporary bypass or alternative supply line, if possible • Water sampling and its testing	SDO, Supervisor, Sub Engineer

Hazard Identification & Control Measures

Sr. No.	Hazard Type	Problems with associated hazard	Control Measures	Key Responsibility
2	Structural Hazard	• Contamination due to poor jointing • Deterioration of pipe materials • Ingress of contaminated water from leaking valves	• Apply periodic Inspection of supply lines • Gradual replacement of old aged pipe infrastructure • Exercising of valves	SDO, Supervisor, Sub Engineer

Hazard Identification & Control Measures

Sr. No.	Hazard Type	Problems with associated hazard	Control Measures	Key Responsibility
	Reservoir			
1	Microbial hazard	• Poor water quality due to inadequate disinfection method • Shorter detention times	• Minimizing ingress of contamination to system and lengthening reservoir detention times • Fitting alarms triggered by low disinfectant level • Ensure inspection covers and ventilator covers remain in place	SDO, Supervisor, Sub Engineer

Hazard Identification & Control Measures

Sr. No.	Hazard Type	Problems with associated hazard	Control Measures	Key Responsibility
2	Structural failure hazard	• leakage through reservoir • leakage from partially open valves • taste in water due to internal corrosion of pipelines • deterioration of internal lining	• Regular reservoir inspections • Proper opening/closing of valves • Proper pipe material as per specifications should be used • Relining/painting of internal surface • Routine inspection to see any failure in piping and lining	SDO, Supervisor, Sub Engineer

Hazard Identification & Control Measures

Sr. No.	Hazard Type	Problems with associated hazard	Control Measures	Key Responsibility
Distribution Supply lines				
1	Microbial and Chemical Hazards	• Low chlorine residual in distribution system • Ingress of contamination due to pressure fluctuations • Reversed flows due to quick opening or closing of valves	• Maintain chlorine residual in the system as per requirement • Pressure Management • Apply flushing of pipelines	SDO, Supervisor, Sub Engineer

Hazard Identification & Control Measures

Sr. No.	Hazard Type	Problems with associated hazard	Control Measures	Key Responsibility
		• Contamination by backflow due to unauthorized connections • contamination during water main repair due to debris, soil or groundwater remaining in the main after repairs	• Disinfection prior to commissioning of water main • Follow design specifications for water supply system	SDO, Supervisor, Sub Engineer

Hazard Identification & Control Measures

Sr. No.	Hazard Type	Problems with associated hazard	Control Measures	Key Responsibility
		• Cross connection between water system and another system carrying non-potable water		
2	Structural failure hazard	• Ingress of contamination due to main burst • Ingress of contamination due to cracks in pipelines • Ingress of contamination due to improper closure of valves	• Maintenance of pipelines and valves • Use of approved pipeline types	SDO, Supervisor, Sub Engineer

Introduction to Ultra Filtration Systems

Filtration is applied to separate non-soluble substance from water by passing it through a porous medium. The goal is to make the water safe for drinking, free of any solids, bacteria, viruses or arsenic substance.

Importance of Filtration Systems.

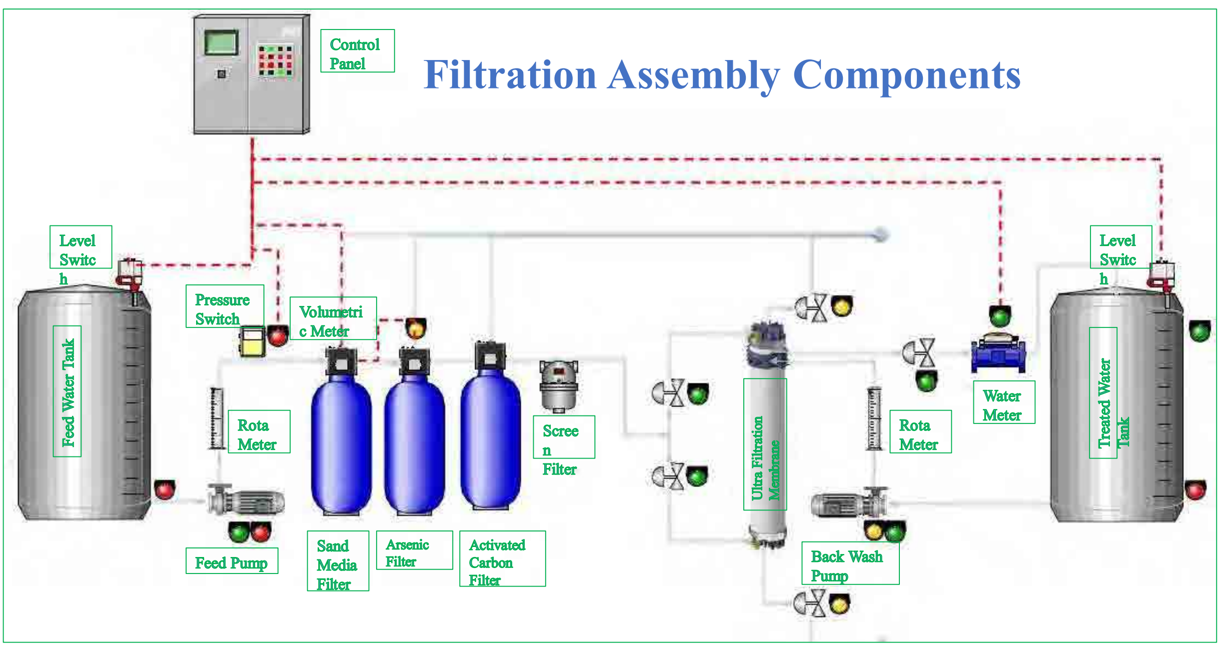
Importance of Filtration system at WASA tube well

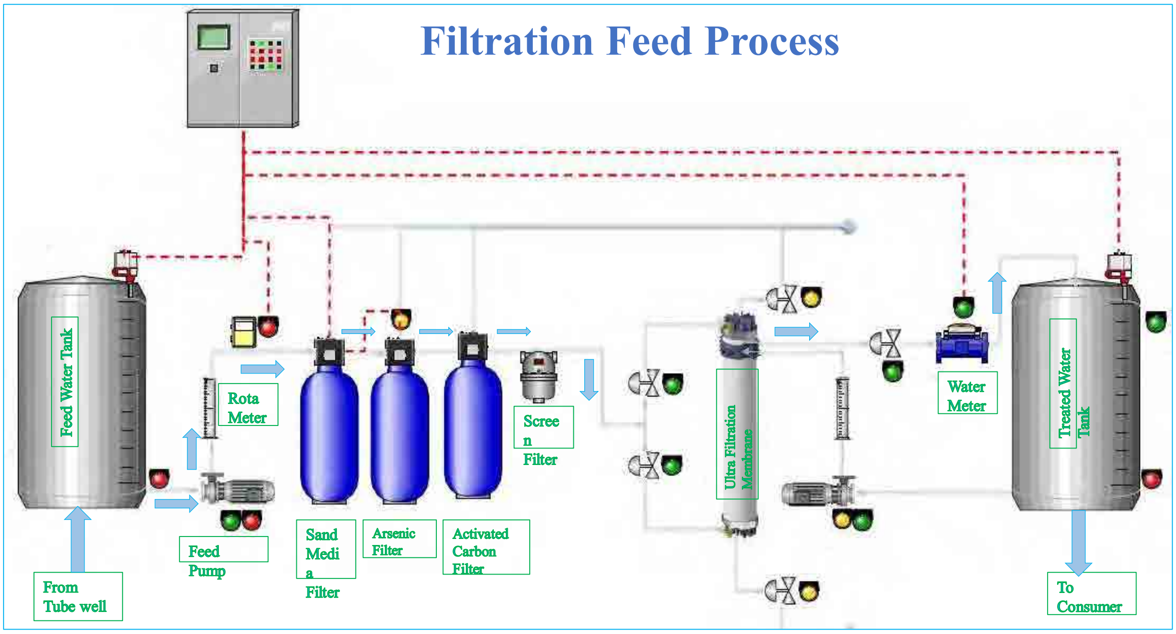
- In LDA – WASA Lahore Project the water filtration process is designed to remove pollutants which are Turbidity, Bacteria, Arsenic and heavy metals.
- Raw water will feed to Raw Water Storage Tank capacity 2,000 liter.
- Each plant has capacity of 4000 LPH.
- The water treatment process will start from raw water storage tank duly connected with the WASA tube-well or water supply line.

Main components of ultra filtration systems

- ✓ Raw water feed pump
- ✓ Raw water tank
- ✓ Feed and Backwash pumps
- ✓ Flow meters
- ✓ Pressure gauge
- ✓ Solenoid valves
- ✓ Sand filter
- ✓ Arsenic filter
- ✓ Carbon filter
- ✓ Y type strainer
- ✓ UF membrane
- ✓ Water meter
- ✓ Clean water tank
- ✓ Drain pipe

Filtration Assembly Components





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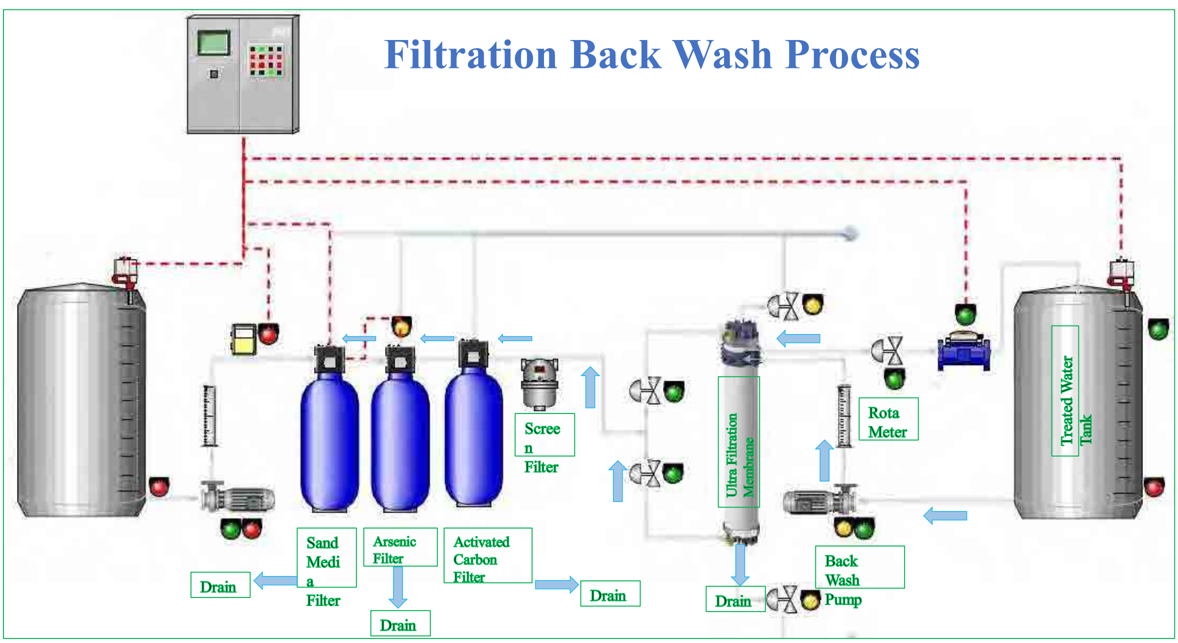

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Operation of Filtration system

Pre Filtration Vessel

Function Flow Control Valve divided into 3 modes.

- ***Service Mode:*** Control water to flow as Downstream to filtrate. Water entrances Filtration Vessel at "Water Inlet" port and leaves at "Water Outlet" port.
- ***Back Wash Mode:*** Control water to flow as Upstream to back wash particles on the surface of filter media. Water entrances Filtration Tank at "Water Inlet" port and leaves at "Drain Outlet" port.
- ***Fast Rinse Mode:*** Control water to flow as Downstream to rinse. Water entrances Filtration Vessel at "Water Inlet" port and leaves.

Troubleshooting of Filtration System

ULTRA-FILTRATION Troubleshooting

TROUBLE	CAUSE	Solution
1. ULTRA-FILTRATION system does not work.	▪ Electrical control equipment is out of order. (Low Level Switch, High Level Switch and High Pressure Switch)	Check the electrical control system and replace damaged electrical control equipment.
	▪ A solenoid valve is damaged.	Check and change a coil of solenoid valve.
	▪ A ball valve is totally closed.	Check and open the ball valve. (BV2and BV3)
	▪ Any filtration tank, Screen Filter or ULTRA-FILTRATION membrane is clogged.	Check and Clean or Back wash it.
	▪ Feed Pump is out of order.	Check and repair or replace one if necessary.

Troubleshooting of Filtration System

ULTRA-FILTRATION Troubleshooting

TROUBLE	CAUSE	SHOOTING
2. Bacteria are present.	An ULTRA-FILTRATION membrane is damaged.	Check by the Integrity Test. Repair a broken fiber.
3. Flood flow rate decreases.	An ULTRA-FILTRATION membrane is clogged.	1. Back wash. 2. CEB is necessary.
	A filtration Tank or Screen Filter is clogged.	Back wash or Clean.
4. ULTRA-FILTRATION drainage water flows at all times.	A solenoid valve has a problem.	Check and clean up inside a solenoid valve or replace one if necessary.

O & M of Mechanical Equipment
WSD 5231

Heavy Machines

Module 3

ALJAZARI
ACADEMY

Agenda

- ✓ Ice Breaker and Class Introduction
- ✓ Resources and handouts
- ✓ Equipment overview
- ✓ Assembly components

- ✓ Standard operating procedures
- ✓ Preventive maintenance
- ✓ Selection process

Icebreaker and Class Introduction

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

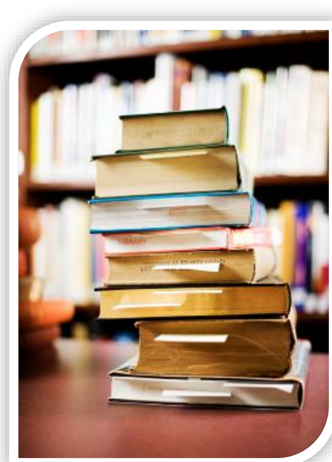
Now it is your turn…

- Degree and backgrounds?
- Share your work experience relative to heavy equipment?

- Any prior experience on heavy equipment?
- Why interested in this module?
- What best skills do you bring to the class?

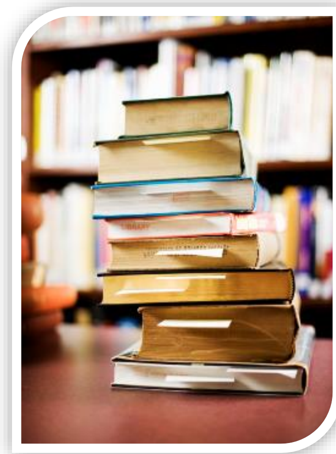
Resources and Handouts

- Owner's Manual, Hino Pak
- Kissan Engineering Operating Manuals (Suction and Jetting Unit)
- Participant lecture notes, Module 5
- Class presentations, Module 5

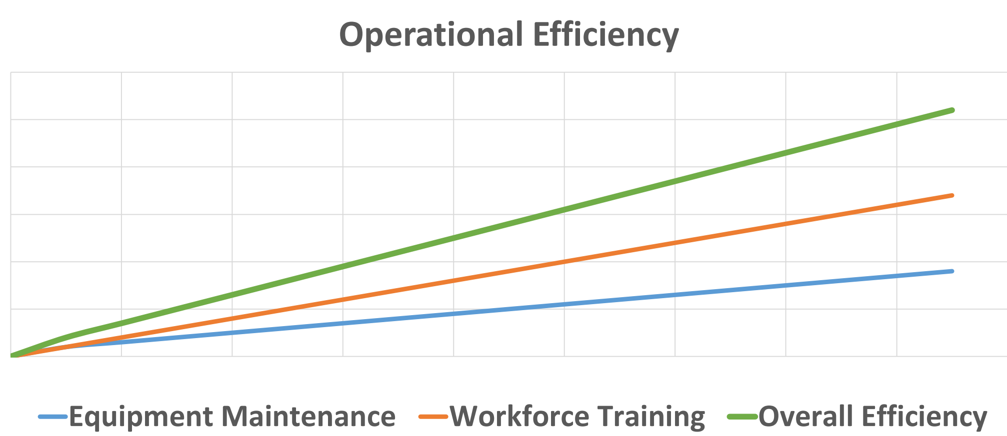


Resources and Handouts

- Heavy Equipment, Orlemann, Enthusiast Books, Madison, E. (2009)
- O and M Manual, Diesel Engines, Doosan, Doosan, Seoul
- JICA, Manual on sewerage and sewage treatment, Part B: Operation and Maintenance, Ministry of Urban Development, New Delhi



Importance of Equipment and Skills



Equipment Overview

Sr. No.	Name of Machinery	Total Machinery in Lahore, Towns						Total
		RT	ST	GBT	NT	IT	Drain	
1	Muck Sucker	12	6	11	8	10	3	50
2	Jetting Unit	11	6	12	8	9	3	49
3	Water Tankers	4	3	5	4	3	2	21
4	Tractor Trolley	4	6	6	4	5	9	34
5	Crane	3	3	1	2	1	-	10
6	Dump Trucks	1	-	1	-	-	69	71
7	Backhoe Tractors	1	-	-	-	-	29	30
8	Excavator	-	-	-	-	-	15	15
9	Trencher	-	-	-	-	-	2	2
10	Front-End Loader	-	-	-	-	-	5	5
11	Wheel Loader	-	-	-	-	-	2	2
12	Mazda Truck	1	1	1	1	-	-	4
13	Tractor	1	-	1	-	-	-	2
14	Dewatering set	-	-	343	-	-	-	343
15	Generators	38	41	67	19	29	4	198
16	Winch Machine	4	2	1	1	3	0	11
	TOTAL	80	68	449	47	60	143	847

Importance !!!

This could be in front of my home !

Equipment Overview

How would you like to do it?

Manually or with machines ?

Equipment Overview

Velocity Cleaners (Jetting Units)

- ✓ It is a high pressure, heavy duty three plunger pump mounted on a Nissan, Isuzu or Hino truck.
- ✓ Used to to remove the blockage of sewer lines and drains
- ✓ High pressure water jetting action loosens or breaks solid waste to remove blockage

Equipment Overview

Velocity Cleaners (Jetting Units)

Example Specifications:

✓**Dimension**	=	24.9 ft (L) x 8.2 ft (W) x 10.9 ft (H)
✓**Total Weight**	=	12,455 Kg
✓**Water Tank capacity**	=	4500 liters
✓**Pressure Range**	=	0 to 2843 PSI
✓**Jetting Hose Reel Length**	=	~ 60 M

Equipment Overview

Vacuum Cleaners (Suction Unit)

- ✓ Suction units create the vacuum required for siphoning of mud, slurry, grit and other materials from sanitary
- ✓ It is water sealing type vacuum pump vane having air cooling system capable of creating 90% vacuum mounted on a truck with PTO system or auxiliary engine (prime mover)
- ✓ Used to empty flooded sewerage lines and to clear blockage in combination with jetting unit

Equipment Overview

Vacuum Cleaners (Suction Unit)

Example Specifications:

- ✓ **Dimension** = 25.9 ft (L) x 8.2 ft (W) x 11.0 ft (H)
- ✓ **Total Weight** = 14,975 Kg
- ✓ **Water Tank capacity** = 4000 liters
- ✓ **Vacuum Pressure** = - 1 to -14 psi (~ - 0.97 bar)

Equipment Overview

Vacuum Cleaners (Suction Unit)

- ✓ **Suction Hose:** 100 mm diameter x 5 meter hose of heavy duty flexible PVC.
- ✓ **Flushing Hose:** 100 mm diameter hose for cleaning/ flushing of tank.
- ✓ **Water and sludge level indicator**: There are two types of sludge and water level indicators.
    - ✓Transparent water & sludge level indicator
    - ✓Alarm Type (not on all machines)

Equipment Overview

Gauges and Valves

- ✓ **Gauges**: Pressure and Vacuum gauges.
- ✓ **Safety Valves**:
  - ✓ auto safety valve for the vacuum pump to avoid over loading
  - ✓ auto safety valve for the pressure pump to avoid over loading



Equipment Overview

Gauges and Valves

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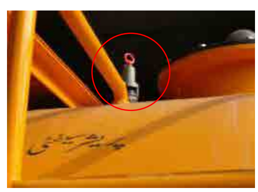
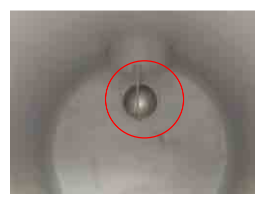



Equipment Overview

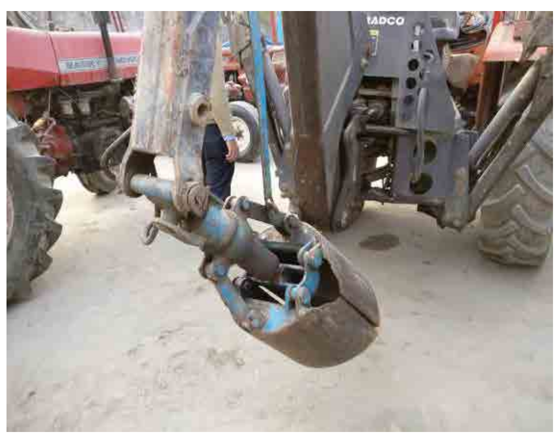
Backhoe

- ✓A backhoe loader is a versatile earth-moving equipment, multipurpose machine.
- ✓It can be used as an excavator and as a loader.
- ✓A backhoe attachment can be mounted or adjusted to allow digging along the walls.

Equipment Overview

WASA Backhoe

Koyker Backhoe with regular bucket

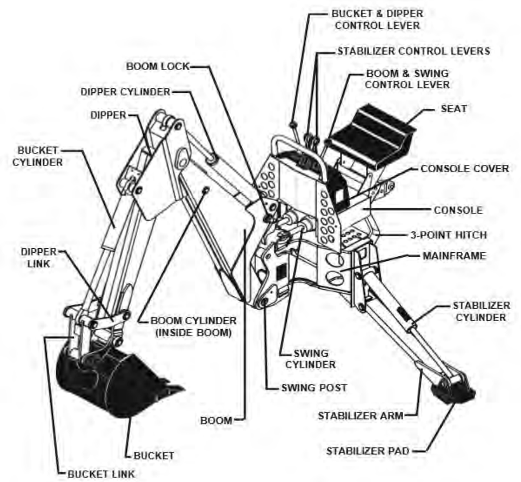


Bradco Backhoe with clamshell bucket (customised)

Equipment Overview

WASA Backhoe (Bradco, 3509)

- ✓**To be mounted ONLY on Category II tractors with 50 - 120 horsepower**
- ✓**2400 to 5000 lbs lift capacity**
- ✓**12000 lbs. GVW**



Equipment Overview

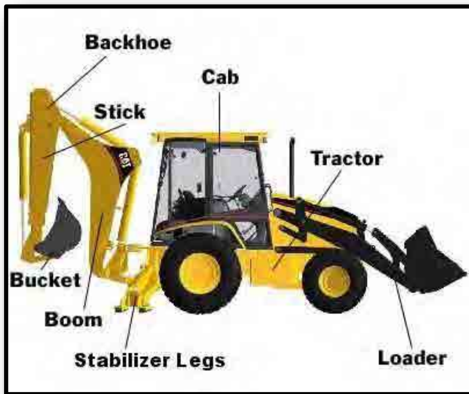
WASA Backhoe (Koyker, KB85)

- ✓**To be mounted ONLY tractors with 30 - 60 horsepower**
- ✓**Lift at end of boom capacity 733 lbs.**

Equipment Overview

Backhoes have many uses:

- ✓ Digging trenches and holes
- ✓ Demolition work
- ✓ General grading and landscaping
- ✓ Heavy lifting such as the lifting and placement of pipe



Equipment Overview

Dump Trucks

- ✓ Dump trucks, as the name implies, are equipped with underbody hoists and are used to haul such as soil, sand, stone, gravel, dirt or hot asphalt in construction, road building and surface mining applications.

- ✓ Dump Trucks are available in various capacities depending upon the base vehicle.

Equipment Overview

Dump Trucks

- ✓ Available from 3 ton to 18 tons
- ✓ Control for Tipping & lowering located in driver's
- ✓ Single/double acting Imported Hydraulic Cylinder

Equipment Overview

Dump Trucks

- ✓ Available from 3 ton to 18 tons
- ✓ Control for Tipping & lowering located in driver's
- ✓ Single/double acting Imported Hydraulic Cylinder

Equipment Overview

Water Tanker

- ✓ Water is routinely transported from regions where it is plentiful to regions where it is scarce. Several water conveyance and distribution techniques are available, and are actively used in many parts of Pakistan.
- ✓ Water Tankers (also known as water bowsers) can be a rapid means of transporting water to areas in need during the initial phase of an emergency. Water Tanker operations, however, are expensive and relatively time-consuming to administer.

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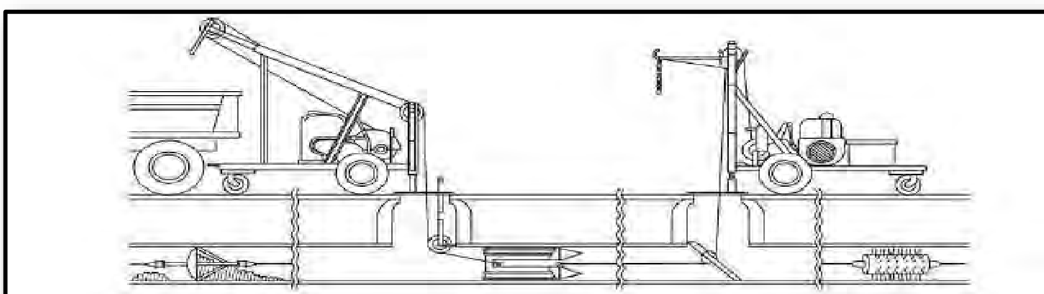
Equipment Overview

Sewer Cleaning Bucket Machine

- ✓ It consists of two powered winches with cables in between for cleaning a section of sewer.
- ✓ It is also used along with other scraping instruments for loosening sludge banks of detritus or cutting roots and dislodging obstructions.



Source: EPA, 2003

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Equipment Overview

General specification:

- ✓Length: 12'2"
- ✓Width: 5'11"
- ✓Height: 8'4"
- ✓Min HP: 25hp
- ✓Axle Configurations: Single
- ✓Max Bucket Capacity: 36"
- ✓Max Cable Length: 1500'

Equipment Overview

Dredger (Clam-shell)

- ✓ It consists of a grab bucket on a wire rope which is lowered into the manhole in the open condition with the help of a crane and pulley.
- ✓ The disadvantage in this system is that it cannot clean the corners of the catch pits of manholes.

Equipment Overview

The clamshell bucket is an attachment used with a crane for:

- ✓ vertical digging belowground level
- ✓ placing materials at considerable height, depth, or distance
- ✓ moving bulk materials from stockpiles to plant bins, loading hoppers, and conveyors
- ✓ to dig loose to medium compacted soil.

Main Assembly Component

Baseline Trucks

- ✓Diesel trucks such as ISUZU N-series, Hino and Mitsubishi are used to build jetting, suction, dumper and water tanker units.
- ✓These trucks offer good options, ease of serviceability and reliable operations if maintained properly

Table 1: Vehicle Specification

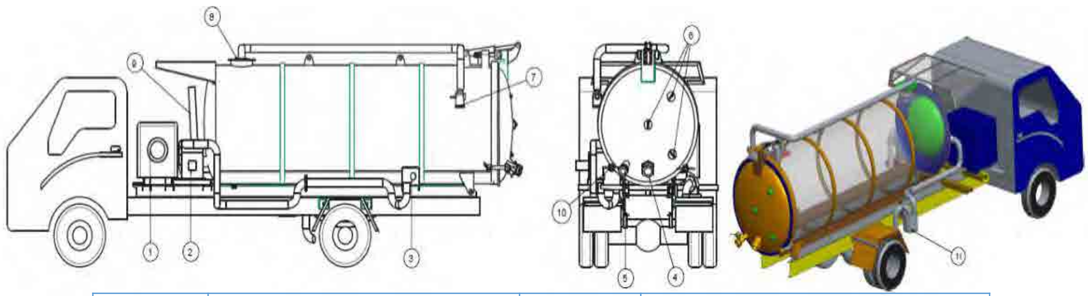
Vehicle Specification: Isuzu N-Series (courtesy RAVI Motors, Lahore)			
DIMENSION & WEIGHTS (Chassis only)		Short Wheel Base (SWB)	Long Wheel Base (LWB)
Wheel Base (WB)	mm	2460	3360
Overall Length (OAL)	mm	4610	5830
Overall Width (OW)	mm	1695	1695
Overall Height (OH)	mm	2120	2120
Tread Front (AW)	mm	1385	1385
Tread Rear (CW)	mm	1425	1425
Road Clearance	mm	190	190
Gross Vehicle Weight	Kg	5200	5200
Curb Weight	Kg	1670	1740
Pay Load	Kg	3530	3460
Fuel Tank	Litre	75	100

Vehicle Specification: Isuzu N-Series (courtesy RAVI Motors, Lahore)	
ENGINE	
Model	4JB1
Type	Diesel Engine, 4 Cylinder, OHV, Direct injection, water cooled
Displacement	2771 cc
Max Output (ps)(kw) / rpm	(80 ps) (59kw) / 3600 rpm
Torque (kgm)(N.m) / rpm	(17.8 Kgm) (175 N.m) / 2000 rpm
CLUTCH	
Type	Dry single Plate with diaphragm spring, Hydraulic Control
Size	240 mm
TRANSMISSION	
	Manual (5+1) with Synchronizers
AXLE	
Front Axle Type	Reverse Elliot, I-beam

Vehicle Specification: Isuzu N-Series (courtesy RAVI Motors, Lahore)			
Rear Axle Type	Banjo fully floating type		
SUSPENSION			
Front & Rear	Semi-elliptical alloy steel leaf spring, hydraulic double acting telescopic shock absorber.		
BRAKE			
Service Brakes Type	Hydraulic, dual circuit front two leading and Rear two leading.		
Parking Brakes Type	Mechanical expanded type at rear of transmission		
STEERING			
Type	Recirculating ball with integral power assisted.		
WHEEL & TYRE			
Type	7.00 x 16 – 14 PR		
No. of Tyres	7 including one spare tyre		
ELECTRICAL SYSTEM			
Battery	1 x 12V – 80 AH		
Generator	12V / 50A		

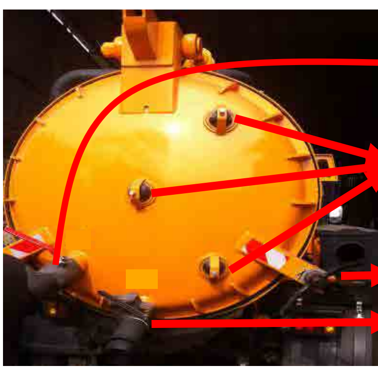
Videos for vehicle systems

Main Assembly Component, **Suction Unit**



Parts No.	Description	Parts No.	Description
1	Auxiliary Engine	7	Secondary cutoff Protection
2	Vacuum Pump	8	Primary Cutoff Protection
3	Filter	9	Telescopic/Hydraulic Jack
4	Drain Valve	10	Dish Open/Lock Handle
5	Suction Valve	11	Silencer air exhaust from pump
6	Level Indicators	12	

Main Assembly Component, **Suction Unit**

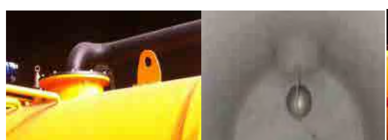


Suction Valve and Pipe attachment

level Indicator

Dish open/lock handle

Drain Valve



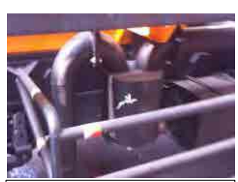
Primary CUTTOFF Protection

Secondary CUTTOFF Protection

Auxiliary Engine or Prime Mover

Vacuum Pump

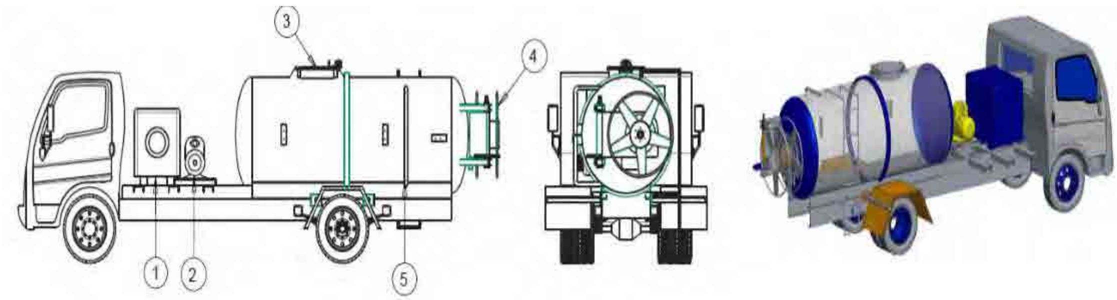
Vacuum Pump Air intake Filter



Air outlet Silencer

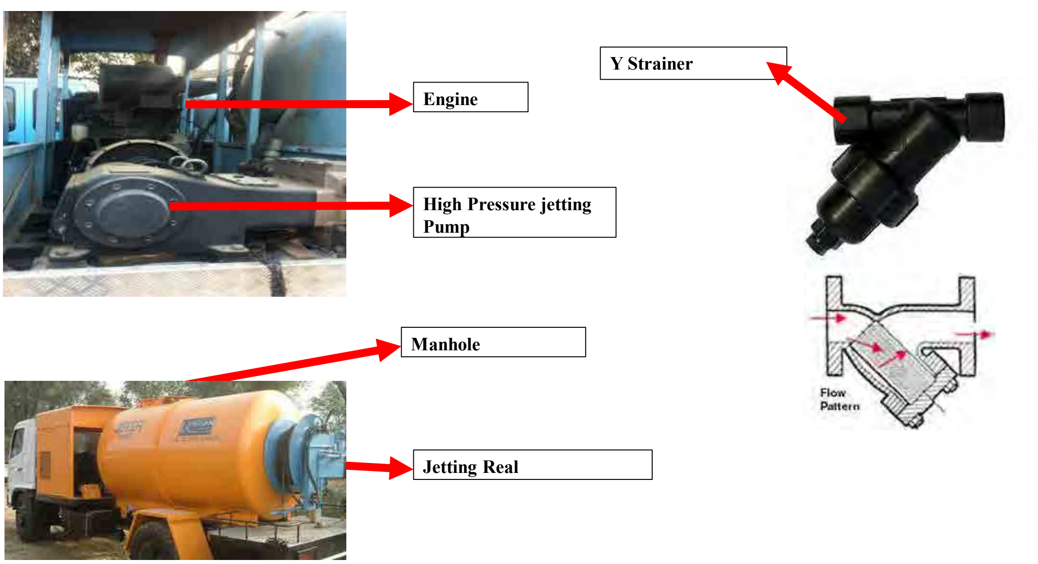
Hydraulic Jack

Main Assembly Component, **Jetting Unit**



Parts No.	Description	Parts No.	Description
1	Auxiliary Engine	4	Jetting Real
2	High Pressure jetting Pump	5	Water Level Gauge
3	Manhole for water refill	6	Y Strainer

Main Assembly Component, **Jetting Unit**



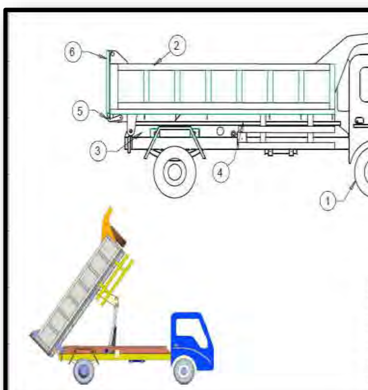
Main Assembly Component

Combined Jetting and Suction Unit

Combined Unit (suction off PTO, Jetting with axillary pump 150 to 200 bar)

Main Assembly Component

Dump Truck



ITEM	Description
1.	Vechile
2.	Body
3.	Sub Frame
4.	Hydraulic Jack
5.	Automatic Door lock
6.	Back Door

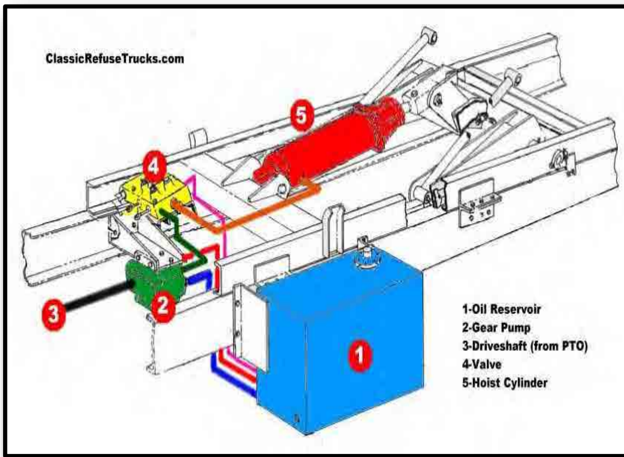
Dump Truck Components

Dump Truck (courtesy Kisaan Engineering)

Main Assembly Component

Load Capacity

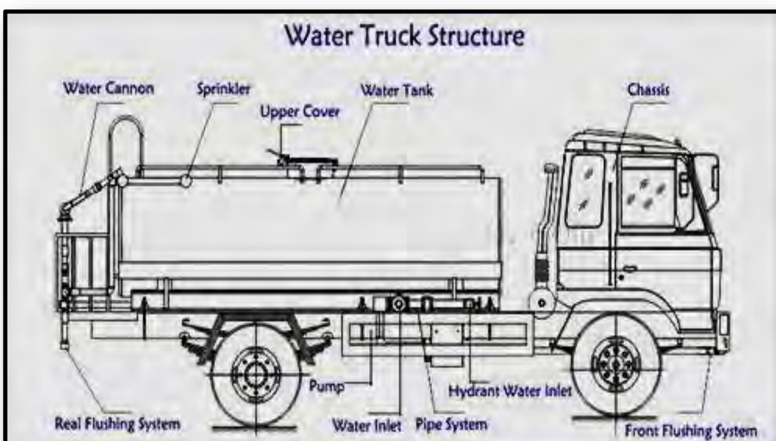
- ✓ 4 Ton or 3.3 cubic yards of dirt
- ✓ Average commercial dump truck holds anywhere from **10 to 14 cubic yards** of dirt.
- ✓ The Dump Trucks used at local service facilities are much smaller with a capacity of 5 to 10 cubic yards of dirt.



Dump Truck (courtesy Kisan Engineering)

Main Assembly Component

Water Trucks



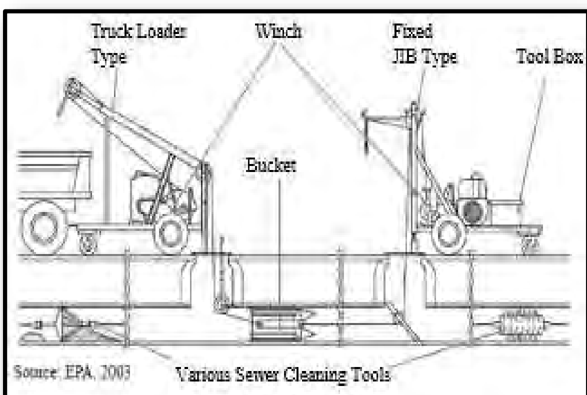
Water Tanker Components

Main Assembly Component

Water Tanker Centrifugal Pumps (PTO and stand-alone engine driven)

Main Assembly Component

Bucket Machine



Bucket Machine Components

Bucket Machines

Main Assembly Component

Solution to Problem	Emergency Stoppages	Grease	Roots	Sand, Grit, Debris	Odors
			Type of Problem		
Balling		●		●	●
High Velocity Cleaning	•	●		●	●
Flushing					●
Sewer Scooters		●		●	
Bucket Machines, Scrapers				●	
Power Rodders	●	•	●		
Hand Rods	●	•	●		
Chemicals		●	●		●

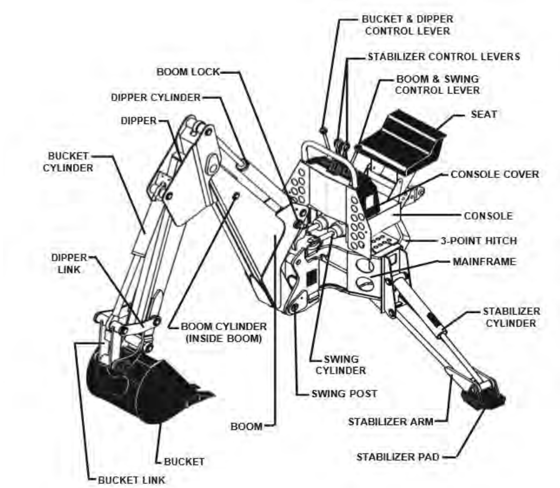
● = Most effective solution for a particular problem

• = Least effective solution for a particular problem

Bucket Machine effectiveness relative to sewer problems (source EPA)

Main Assembly Component

Backhoe



Main Assembly Component

Components of a Backhoe

✓**Superstructure:**

a. The main frame work of the equipment structure
b. Also contains:
   i. Power source (i.e., engine compartment)
   ii. Main hydraulic pump and various hydraulic valves
   iii. Cab house operator's compartment and controls

✓**Undercarriage:**

   i. Axles front and rear
   ii. Drive train

Main Assembly Component

✓**Front end attachments**

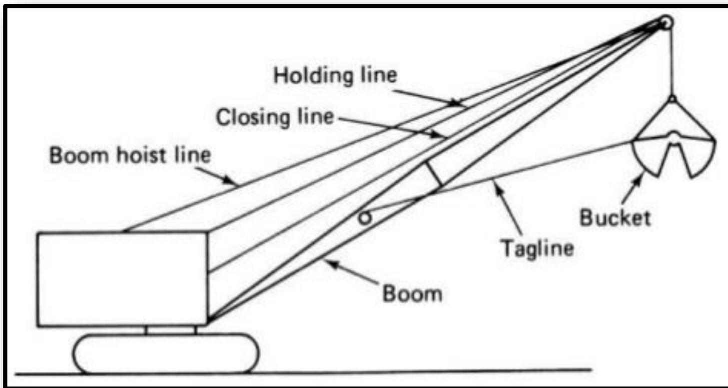
i. Bucket standard or four-in-one clam

✓**Rear attachments**

i. Dipper wrist cylinder
ii. Bucket or dipper
iii. Lift or hoist hook
iv. Compactor
v. Pavement breaker
vi. Outriggers

Main Assembly Component

Dredger (Clam-Shell)



Dredger (Clam-Shell) Components

Standard Operating Procedures

Jetting Unit

1. Climb and transport the truck to the work site.

2. Park the vehicle such that the hose reel is as close as possible to the work area.

3. Start the auxiliary Engine, unwind the pipe and insert almost 3 feet of hose pipe in the line to be cleaned.

Standard Operating Procedures

4. Increase the speed of the Engine until the pressure gauge shows a pressure of 150 bar or 2000PSI.

5. As the hose starts moving in the sewer line unwind the reel bit by bit.

6. After the work completion, wind the pipe on the hose reel again using the control valve.

Standard Operating Procedures

Preventive maintenance

Important Instructions before starting the Auxiliary Engine:

✓Check the engine oil of the auxiliary engine daily before starting the work if the level of engine oil is below the mark, add more engine up to the required level. Only engine oil type CR-40 should be used.

✓Check the condition of the pulleys and belts.

✓Check the fuel filter after every 6 months, in case of blockage change the filter.

✓Clean the air filter regularly depending on the usage of engine. If the engine is used with chocked filter it may be harmful to engine.

✓Use good grade of fuel for better performance of the engine and pump

Standard Operating Procedures

Important Instructions before starting the pump:

- ✓Check the pump for any types of abnormal sounds, any abnormal sounds produced by the pump is a matter of concern. In case of any abnormal sound, stop the pump immediately and check for the reason of the sound.
- ✓Check if the blades of the pump are worn out, replace if needed.
- ✓In this case contact the service department of the manufacturer.
- ✓Clean pump on weekly basis, this increases the efficiency and life of the pump.
- ✓The air intake can get clogged if dust particles get settled in it, so it needs to be cleaned at least once a week.
- ✓Check for proper oil level
- ✓Check for any leakages

Standard Operating Procedures

Suction Unit

1. Suction inlet fitted with quick coupling and revolving boom is provided for ease of operation. Take out the suction hose from carrier and couple it with the quick coupling.
2. Select appropriate suction inlet position according to location of sewer.
3. Starting Truck Engine & Engaging P.T.O

Standard Operating Procedures

4. Set PTO speed by rotating accelerator knob
5. The vacuum pump operating lever has three positions.

   V =Vacuum

   N=Neutral

   P=Pressure

   Turn lever to neutral position.

Caution: Check the level of disposable oil in the vacuum pump by means of dipstick.

Standard Operating Procedures

6. Tighten all clamps and start sludge suction operation.

Vacuum pump will start. At -0.6 bar open ball valve of inlet suction hose to commence suction of sludge.

Note:

a) Ensure Oil is dripping on the Bearing While the pump is operating.

b) Pump consumes oil and should never run dry.

Standard Operating Procedures

7. Keep observing the sight glass carefully. Stop the pump as the top most sight glass is half full.
8. Disengage PTO by Pushing vacuum pump lever in neutral position and place suction hose into the hose carrier.The vehicle can now be transported to dumping site.
9. Connect the hose (if required) with a 4” ball valve at the rear of tank for discharge.

Standard Operating Procedures

10. The tank will be emptied by 4" outlet valve. However, to remove sludge which may deposit inside the tank, the rear dish can be opened.

11. Vacuum pump consumes oil. Check oil before starting pump. Change vacuum pump oil after every two months.

Standard Operating Procedures

Dump Truck

✓**Prior to start and start-up**

1. Site hazards associated with dump truck operations are identified and safe operating techniques are used to minimize risk.
2. Engine power is managed to ensure efficiency of truck movements and to minimize damage to the engine and gears.
3. Engine power is coordinated with gear selection ensuring smooth transition and operation within torque range

Standard Operating Procedures

4. Dump truck is operated to work instructions under varied site and weather conditions in accordance with safe work practices and company operating procedures.
5. Road/traffic conditions are constantly monitored. Vehicle is brought to a halt without injury to personnel or damage to property, equipment etc using straight line braking techniques.

Standard Operating Procedures

✓**Load, transport and tip materials**

6. Vehicle is positioned at load and discharge points with a minimum of maneuver
7. Dump truck movements are smooth and well controlled.
8. Weight and distribution of load is assessed for type of material and size of vehicle to ensure it is within vehicle capacity.
9. Safety and security of load, including load cover requirements, are maintained from loading site to discharge site
10. Load is discharged on slope and/or over face at fill site.
11. Material is dumped/spread evenly.
12. Tray is cleared, lowered and secured before resuming travel.

Standard Operating Procedures

✓**Park and Maintenance in accordance with organization's requirements**

13. Dump truck is safely parked, prepared for maintenance and shut down
14. Inspection and fault finding are conducted
15. Defective parts are removed and replaced safely and effectively
16. Regular programmed maintenance tasks are carried out

Standard Operating Procedures

✓**Clean up**

17. Work area is cleared and materials disposed of or recycled in accordance with project environmental management plan
18. Vehicle, tools and equipment are cleaned, checked, maintained and stored in accordance with manufacturers' recommendations and standard work practice

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Standard Operating Procedures

Water Tanker (Bowser, General Purpose)

1. Always perform pre-operational checks before putting a water truck in operation
2. Never operate a water truck without a thorough understanding of the rules at the construction site, as well as safe operating procedures of the truck
3. Make sure you allow sufficient time to warm the truck
4. Always wear your seat belt.

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Standard Operating Procedures

5. Stay attentive - Watch for possible hazards (equipment and workers)
6. Adjust mirrors before your trip and use them often to monitor the activity around you
7. Confirm that regular maintenance is performed, making sure braking systems are maintained according to manufacturer specifications
8. Operate water trucks on safe haul roads (areas designed for vehicles)
9. Drive Smoothly .Make smooth turns and lane changes.
10. If you must make a quick stop, use controlled or stab braking.
11. If you lose brake pressure during, pull the emergency brake and use the manual transmission to stop the truck.

Standard Operating Procedures

Inspecting Tanks:

12. On all tank vehicles, the most important item to check for is leaks. Check under and around the vehicle for signs of any leaking. Don't carry liquids or gases in a leaking tank. **In general, check the following:**
13. The tank's body or shell for dents or leaks.
14. The intake, discharge, and cutoff valves - Make sure the valves are in the closed position except when loading or unloading.
15. The pipes, connections, and hoses for leaks, especially around joints.
16. The manhole covers and vents.

Standard Operating Procedures

Liquid Surge:

17. Liquid surge results from movement of the liquid in partially filled tanks. For example, when coming to a stop, the liquid will surge back and forth. When the wave hits the end of the tank, it tends to push the truck in the direction the wave is moving.

18. If the truck is on a slippery surface, the wave can shove a stopped struck into an intersection. Remember: A half-full tank is more dangerous than a full tank!

Standard Operating Procedures

Baffled Tanks:

19. Baffles allow the liquid flow through and helps control the forward and backward liquid surge. However, side to side surge can still occur which can cause a rollover. Drive slowly and be careful in taking curves or making sharp turns with a partially or fully loaded tanker.

Non-baffled Tanks:

20. Smooth bore tankers have nothing inside to slow down the flow of liquid. Therefore, forward and back surge is very strong. Be extremely cautious (slow and careful) when driving smooth bore tanks, especially when starting and stopping.

Standard Operating Procedures

Special add on guidelines for Water Tankers on drinking clean water supply:

1. All water supplied in bulk form must originate from a regulated drinking water system, registered with the government according to Drinking-Water Systems Regulation.
2. At the time of filling, all water sources are currently potable (i.e., not under a boil water/drinking water advisory) and meet the WHO requirements**.**
3. The water tank and any equipment used to supply water shall not have been previously used to transport a noxious, hazardous, or toxic substance or liquid.
4. The interior surface of water tanks shall be constructed with a food-grade material that is non-corrosive (i.e., stainless steel, fiberglass, plastic) and shall not be used for any other purposes.

Standard Operating Procedures

5. With the exception of cleaning, emptying or filling of the tank, the inlet or opening must be covered and sealed at all times.
6. Hoses and nozzles must be covered when not is use and disinfected before each use to avoid disinfection.
7. Food-grade lubricants shall be used if the pumps are used for the transmission of drinking water to or from the water haulage vehicle.
8. Ensure the water tank and any removable equipment (i.e., hoses) are permanently labeled with the words “Drinking Water” or “Potable Water” in letters at least 15cm (6”) high on the water tank.
9. The water tank shall be cleaned and disinfected in accordance with the Guidelines for Disinfecting a Water Haulage Tank Water Quality Standards.
10. Appropriate measures must be taken to protect the water from contamination.

Standard Operating Procedures

Guidelines for Disinfection a Water Haulage Tank

11. Disinfection of the water tank must be conducted on a monthly basis. **The following procedure requires the use of unscented household bleach (5.25% sodium hypochlorite)**
12. Shut off valve to water tank distribution lines. Drain all water from the bulk tank.
13. Wash and remove dirt from the inside surfaces of the tank by using a high pressure hose.
14. Remove wash water and sediments from bottom of tank. These can be vacuumed out.
15. Rinse inside surfaces of tank with clean potable water. Remove wash water.

Standard Operating Procedures

16. Disinfect the inside surfaces of the tank and distribution lines as follows:
17. Use 1 litre of household bleach for every 1000 litres of water. This provides 50 milligrams per litre chlorine solution. For example: a 3,500 gallon truck will have about 16,000 litres of water.
18. Add bleach while refilling the vehicle with water from the drinking water system. This will ensure thorough mixing of the bleach solution.
19. Ensure the tank is completely filled to allow interior surfaces to come in contact with the bleach solution.
20. Open valve to water tank distribution lines.

Standard Operating Procedures

21. Run water out of water taps in the distribution lines until the smell of bleach is detected.
22. Shut off water faucets and valves to distribution lines. Ensure the tank is kept completely filled to allow a contact time of at least 12 hours
23. After 12 hours, drain all the water from the bulk tank into a municipal sanitary sewer or, if not available, a storm sewer. The tank can now be filled with fresh potable water.
24. Flush water tank by opening valves of distribution lines and running water until no smell of bleach is detected.

Standard Operating Procedures

25. D. Disinfection of hose-end prior to each use
26. Hose end connections must be disinfected before each use.
27. A bleach solution for dipping hose ends can be made with unscented household bleach (5.25% sodium hypochlorite) as follows:
28. 100 ml. of bleach per 10 liters of water or
29. 1/2 cup of bleach per 3 gallons of water.

Standard Operating Procedures

Bucket Machines

Bucket machines are very useful in cleaning medium to large size sewers.

The following steps are usually followed:

1: Make a Way

Before starting cleaning, connection between the two manholes has to be established. Jetting or rodding should be done to establish this connection.

Standard Operating Procedures

2.Preparation

- ✓A light steel wire or rope 5 mm in diameter is drawn through the sewer section.
- ✓"Live winch" is positioned over the manhole on the downstream side of the sewer.
- ✓The "dead winch" over the manhole on the upstream side.
- ✓Wire or rope from the dead winch is tied to the smaller end of the bucket.
- ✓Wire rope from the live winch is tied to the bigger end of the bucket
- ✓Shake block, Snatch block, jacking screw and a manhole tube is used to support the wire or rope in the sewer.

Standard Operating Procedures

3: Operation

- ✓The bucket is pulled through the sewer by the dead end winch.
- ✓The bucket flap pivots to allow free passage of the silt through the bucket.
- ✓Normally bucket should not travel more than 5 to 10 meters at a time.
- ✓As the pull is reversed by the live winch, the bucket flap closes and full load of debris will be brought to the surface.
- ✓The cycle is repeated, progressively drawing further through the sewer. Care should be taken not to damage the fabric of the sewer.

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Standard Operating Procedures

Backhoe

1. Set up the proper work zone control for the area where the work will be performed utilizing the Ohio Manual on Uniform Traffic Control Devices (OMUTCD)
2. Make sure the worksite footing has enough strength to support a backhoe firmly in order to prevent cave-ins
3. Watch for clearance height
   - Know what is above you at all times.

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Standard Operating Procedures

4. Know your weight limitations for lifting capacity
5. Check underground utilities
6. Beware of power lines
   - Stay a minimum of 10 feet from power lines
7. Make sure that lights and warning signs are visible to everyone in the work area

Standard Operating Procedures

Equipment Start-Up

8. The operator must be seated with the seat belt fastened to operate the controls.
9. Start the engine with the throttle control lever set at idle.
10. When the key switch is turned on, the buzzer will sound briefly.

Standard Operating Procedures

11.Buzzer Stop Alarm (if so equipped)

a. The engine buzzer will sound whenever the engine oil pressure is low, the coolant overheats or the hydraulic oil overheats

b. The alarm's location will vary depending on manufacturer

c. The buzzer for low engine oil pressure will not stop until the equipment is turned off

d. For high coolant temperature and high hydraulic oil temperature, reduce

Load immediately and run the engine at reduced engine speed

Standard Operating Procedures

12.Engine coolant temperature gauge

a. The needle will point to the white zone until the engine is warm

- Normal operating temperature is in the green zone

b. Do not stop the engine when the needle enters the red zone or the temperature will farther

c. Instead of stopping the equipment, stop digging immediately and place the equipment at the lower revolutions per minute (RPM) speed recommended by the manufacturer until the temperature drops

- If the problem continues, inspect for a plugged radiator or coolant leakage

Standard Operating Procedures

13.Alternator voltage indicator

a. The indicator will light when there is low voltage output from the alternator

b. Check the battery’s charge and the electrical system

14.Engine oil pressure indicator

a. If the engine oil pressure light (red indicator) comes on and the buzzer sounds while operating, stop the engine immediately

- Cold oil, a low level of oil or operating the equipment at an extreme angle may cause the indicator to light

Standard Operating Procedures

15.Air filter restriction indicator (if so equipped)

a. The indicator will light when the air filter elements are plugged

b. Stop operation of the equipment and clean or replace the elements

16.Hydraulic oil temperature indicator

a. The indicator will light when hydraulic oil overheats

b. The red indicator will light and the buzzer will sound if continue operation will cause damage to the hydraulic components

c. Stop the engine immediately and consult with a mechanic to correct the problem before starting the equipment again

Standard Operating Procedures

17.Hydraulic oil filter restriction indicator (if so equipped)

a. The indicator will light when the hydraulic oil filters are plugged

b. Immediately stop operation and have a mechanic replace the filters

18.Light indicator

• The indicator comes on when work lights (i.e., headlights, boom lights, etc.) are active

Standard Operating Procedures

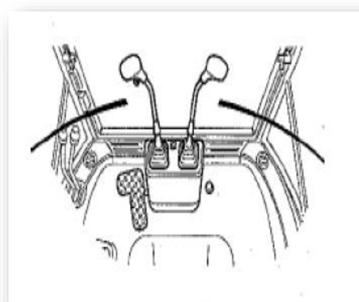
19.Levers

a. Located on either side of the operator's seat

b. Used to control the boom, dipper and bucket

c. Horn button location depends on manufacturer

d. The back-up alarm will sound when the FNR lever is placed in the R position



Standard Operating Procedures

20. Pedals

a. Accelerator and brake pedals are used by the operator to move the machine forward and reverse along with the FNR lever.
b. The dipper extension pedal if a backhoe is equipped with an extension rod.

21. Operating lights (if equipped)

a. Turn on all light switches for driving and to light up the instrument panel
b. Turn on night time operating lights if so equipped

Standard Operating Procedures

22. Warm weather warm-up for the engine

a. Clear the area of all persons before running the machine through the warm-up procedure

b. After the engine starts, run at 1/3 speed for 30 seconds

- 1/3 speed can be achieved by raising the throttle lever to approximately 1/3 of traveling distance from the start position to full throttle

c. Do not run the engine at fast or slow idle and do not accelerate rapidly during the warm up

d. Operate a backhoe at less-than-normal loads and speeds until the engine is at normal operating temperature

Standard Operating Procedures

23. Cold weather warm-up (below 32 degrees Fahrenheit)

a. Clear the area of all persons before running the machine through the warm-up procedure

b. Start the engine and run at half speed for 5 minutes

c. Do not run at fast or slow idle and do not accelerate rapidly during the warm up

d. Confirm that no one has entered the operating area

e. Operate boom, arm and bucket functions by moving cylinders a short distance in each direction for the first time

f. Continue cycling cylinders by increasing the traveling distance during each cycle until a full stroke is reached

Standard Operating Procedures

g. If hydraulic functions still move slowly, repeat the two steps immediately above

h. Safety precautions specific to a cold weather warm-up

i. If hydraulic oil is cold, the hydraulic functions will move slowly

ii. Do not attempt normal backhoe operation until the hydraulic functions move at close to-normal cycle times.

iii. In cold conditions, an extended warm-up period will be necessary

iv. For faster warm-up, cover the radiator and oil cooler during the warming period

Standard Operating Procedures

v. The hydraulic filter restriction indicator may flicker during warm up

vi. Operate functions slowly until the engine and hydraulic oil are thoroughly warmed

vii. Avoid sudden operations of all functions until the engine and until the engine and hydraulic oil are thoroughly warmed up.

24. Moving a Backhoe

a. Prior to traveling over long distances, be sure to lock boom in place and ensure the slow moving vehicle sign is on the back of the backhoe and visible to the public

b. Insert swing lock pin

c. Select gear for travel speed and place FNR lever in the F position

Standard Operating Procedures

d. If traveling a long distance put the transmission in 3rd or 4th gear (depending on the distance which will be traveled) then put the FNR lever in the F position

e. If roading, LOCK brake pedals together; this ensures even braking power to each wheel.

f. Always drive the backhoe carefully.

g. During freezing weather, park the machine on a hard surface to prevent freezing to the ground.

i. Clean debris from tires and frame daily.

ii. If tires are frozen to the ground, raise the tires one at a time using the boom and move the machine carefully to prevent damage to the drive train and tires.

Standard Operating Procedures

h. Do not drive a backhoe with the arm cylinder fully extended

- Retract the arm cylinder slightly to prevent cylinder damage

i. Throttle control lever

ii. Use the engine speed control lever to set engine speed at desired RPMs

iii. To be used when digging only

Standard Operating Procedures

25. Stopping the engine

a. The turbocharger may be damaged if the engine is not properly shut down

b. Before leaving the operator's seat, perform the following steps

i. Park the machine on a level surface

ii. Set parking brake

iii. Lower the front bucket to the ground

iv. Lower the boom and dipper to the ground

v. Lower the outriggers

vi. Run the engine at half speed without load for 2 minutes

Standard Operating Procedures

vii. Push the speed control lever to the idle position
viii. Turn the key off
ix. Remove the key from the switch

26. Operating a Backhoe Digging Mechanism

a. Pilot control shut-off lever (if equipped)

b. This lever is the shut-off point for all hydraulic controls

i. Locking the switch in place will render a backhoe's lever inoperable

ii. Pull shut-off lever back to lock position to shut off hydraulic pressure to both right and left control levers and foot pedals

Standard Operating Procedures

27. Control levers

a. These levers are utilized to operate the boom, dipper, and bucket

b. When the lever is released, it will return to neutral

c. Read the operator's manual for directions on how the equipment controls are designed to work

i. Cleaning

ii. Keep the operator's cab clean

Standard Operating Procedures

28. Operating in water or mud

Be careful not to operate the machine in water or mud above the swing pin. Causing the swing pin to be submerged will cause excessive wear.

Standard Operating Procedures

29. Starting an excavation

a. Prior to starting the excavation, ensure the proper bucket has been selected for the job to be completed.

b. Place the machine on level ground and use the stabilizers before digging

- This creates a level-bearing stable surface for the tracks.

c. Position the arm slightly forward of the perpendicular position.

Standard Operating Procedures

d. Place the bucket teeth on the ground with the bottom of the bucket at approximately a 45 degree angle to the ground

e. Pull the bucket toward a backhoe using the dipper arm, boom and bucket functions until the bucket is full of material

- Continue this procedure until the desired depth is reached

30. **Straight line trenching**

a. The process by which a straight line dig is dug:

i. Drive two stakes in at the beginning of the excavation process.

ii. Drive the first stake in immediately behind the starting point and the second stake approximately 30 feet behind the first.

Standard Operating Procedures

iii. Positioning these stakes in a line extending from the centerline of the operator’s position enables you to use them as a sight gauge

iv. This technique is especially useful where frequent repositioning of a backhoe is needed

31. Moving a backhoe off an embankment

a. To move a backhoe off an embankment, position the bucket with the flat surface resting on the ground

- The angle of the boom should be perpendicular to the operator

Standard Operating Procedures

b. The bucket must always be placed on the ground before beginning to move off the embankment; never move the machine and the bucket simultaneously off the embankment

- If the machine and the bucket are moved simultaneously off the embankment, there is a great risk of the bucket absorbing the force of the fall, damaging the equipment

c. The bucket must be on the ground before the machine begins to tip

d. As the unit moves forward, raise the boom and retract the arm until the tires reach the lower ground level

Standard Operating Procedures

e. Raise the bucket off the ground

f. Position the front bucket on the upper ground with the flat surface of the bucket resting on the ground

- Keep the stabilizers up about 1 foot

g. Place the FNR lever in R and slowly backup keeping pressure on the front bucket

h. When the tires clear the embankment, raise the front bucket to lower the tires onto the lower ground level

i. To move a backhoe onto an embankment, reverse the procedure

Standard Operating Procedures

32. Craning/overhead lifting

a. The process of using a sling attached to the bucket to move a heavy item (such as a catch basin) from one point to another.

i. Secure sling/chain tightly to the load being lifted, always using grade 80 chain

a) Many buckets are equipped with a bucket loop through which the chain for the sling can be secured

b) If your equipment has a bucket loop, use when securing the sling/chain

ii. Coordinate hand signals with your designated ground guide before starting

iii. Know the location of all persons in the working area

iv. Attach a hand line to the load and make sure the person holding it is away from the load

Standard Operating Procedures

v. Before starting the job, test your load by doing the following:

a) Park the machine close to the load

b) Attach the load to the machine

c) Raise the load 2 inches above the ground

d) Swing the load all the way to one side

e) While keeping the load close to the ground, move it away from the machine

f) If there is any indication of reduced machine stability(i.e., tipping starts to occur), lower the load to the ground to reposition boom and dipper

vi. Lift the load only as high as necessary when moving

Standard Operating Procedures

b. Safety precautions

- i. Never move the load suddenly
- ii. Never move a load over a person's head
- iii. Do not allow anyone near a load
- iv. Keep everyone away from a raised load until blocks are supporting it or the load is set on the ground
- v. Fill the front bucket for more counterbalance and stability
- vi. Never attach a sling/chain to bucket teeth
- vii. Keep load as close to the machines as possible

Standard Operating Procedures

33. Operating on a slope

a. Level off a work area

b. Avoid swinging the bucket farther than necessary in a downhill direction

c. Do not lift the boom too high on the uphill side. A backhoe may tip backwards if the slope is too steep

d. If at all possible, keep your spoil pile (dirt which is being dug out) on the uphill side of your excavation to make it easier to back fill and ensure the pile is a minimum of two feet from the excavation.

Standard Operating Procedures

34. Hydraulic pavement breaker (manufacturer specific)

a. An additional attachment available for the equipment which can be used in lieu of the bucket

b. The pavement breaker functions by using a jack-hammer type effect on the object to be broken apart

c. Refer to the operator's manual for specific instructions on how to use the attachment

d. General operating tips

- i. Perform the required checks and inspection daily before operation
- ii. Avoid entry of contamination into the hydraulic system when switching the breaker with the bucket

Standard Operating Procedures

- iv. Do not operate the breaker with hydraulic cylinder rods fully extended or fully retracted to prevent cylinder or machine damage
- v. Do not operate the breaker in one position for over 1 minute
- vi. Do not use the breaker as a lever or a ripper (extending the hammer fully in front of the operator and pulling the hammer toward the operator while hammering) to prevent damage to the chisel or its holder
- vii. Do not use the breaker to move rocks
- viii. Do not operate the breaker in water
- ix. Operate the hydraulic pavement breaker carefully to avoid hitting it against the object to be broken

Standard Operating Procedures

x. Upon completion of breaker operation, release the pressure from the lines by depressing the breaker control pedal/switch

xi. Failure to release the pressure will shorten the life of the breaker

35. Back blading utilizing the front bucket

a. Place front bucket flat on the ground

b. Tilt bucket slightly forward

c. Backup length of area which needs to be leveled

d. Just prior to the end, tilt bucket back up to feather out material being leveled

Standard Operating Procedures

36. Operating tips

a. Make sure you know the location and function of each control before operating

b. Whenever possible, position the machine on a level surface

c. Do not hit the stabilizers with the bucket when digging

d. Do not use the bucket as a hammer or pile driver

Do not try to shift rocks and break walls using a swinging motion

e. To avoid damaging the cylinders, do not strike the ground with the bucket or use the bucket for tamping (flattening a surface) when the bucket cylinder is fully extended (bucket completely curled under)

Standard Operating Procedures

f. Adjust the length and depth of each cut to produce a full bucket at every pass

g. A full load should be the first objective, followed by speed, in order to increase productivity

h. Do not try to break ledge rock by dropping the front of the bucket on the bucket teeth for penetration—serious damage could result

i. Once a trench is open, ledge rock can be broken by pulling the bucket up under the layers

- The top layers are pulled out first, with one or two layers being lifted at a time

j. Never place any part of your body beyond the window frame

k. When digging, avoid contacting stabilizers with the boom cylinders or the bucket

Standard Operating Procedures

37. Parking a backhoe

a. Before leaving the operator's seat, perform the following steps

i. Park the machine on a level surface

ii. Lower all attachments to the ground

iii. Follow procedure previously mentioned for shutting down the engine

38. Lock all compartments

a. A backhoe is equipped with locks on the cab door and side shields

b. Use these locks to safeguard the machine

c. It is the operator's responsibility to lock the equipment to protect it from vandalism

d. Shut off master switch, if so equipped. The switch will usually be found in one of the compartments.

Standard Operating Procedures

Dredger (Clam-shell)

Clamshell operating procedures are as follows:

1. Position and level the crane, ensuring the digging operation is as close to the radius as the dumping operation. This prevents you from having to boom up and down, resulting in a loss of production.
2. Select the correct size and type of bucket for the crane.
3. When lowering the clamshell bucket, if too much pressure is applied to the closing line brake, the bucket will close and an excess amount of wire rope will unwind from the holding line hoist drum. To avoid this, you should release the holding line and closing line brakes simultaneously when lowering the open clamshell into the material for the initial bite.

Standard Operating Procedures

4. If, during hoisting, the hoist line gets ahead of the closing line, the bucket will open and spill the material. The operator must hoist both the closing and holding lines at the same speed to keep the bucket from opening and spilling material.
5. When the clamshell bucket is raised enough to clear all obstacles, start the swing by engaging the swing control lever. Hoisting the bucket can be performed, as it is swung to the dumping site. The spring-loaded tag line will retard the twisting motion of the bucket if the swing is performed smoothly.
6. Dumping and unloading the clamshell is performed by keeping the holding line brake applied while the closing line brake is released. Apply the closing line brake quickly after the load is dumped to prevent the closing line from unwinding more wire rope than is needed to dump the material. After the bucket is emptied, swing the open clamshell back to the digging site. Then lower the open bucket and repeat the cycle.

Standard Operating Procedures

The clamshell operating cycle has four steps:

- filling (closing) the bucket
- raising the loaded bucket
- swinging
- Dumping

The boom angle for clamshell operations should be between 40 to 60 degrees. Be careful when working with higher boom angles, as the bucket could hit the boom

Preventive maintenance of heavy machines

Why Preventive Maintenance is so important?

There are two types of maintenance strategies employed by companies that rely on equipment

1. Reactive maintenance
2. Preventive maintenance

Here is a look at 7 reasons why preventive maintenance is a much better alternative to reactive maintenance.

1. Cost Savings
2. Improved Safety
3. Increased Equipment Efficiency
4. Decreased Equipment Downtime
5. Improved Reliability
6. Conservation of Assets

Record keeping

- ✓A complete record of operation of each equipment should be present.

- ✓This will help with the future planning of:
  - ✓ equipment work hours
  - ✓ efficient and reliable operations
  - ✓ and for checking the efficiency of the and its drivers

Log book

The log book should record:

- ✓Date
- ✓Operator's name
- ✓Pre-task equipment inspection notes
- ✓Task start and finish time
- ✓Location, time and mileage
- ✓Quantity of material used (if applicable)

Log book

The log book should record:

- ✓Rest periods (mandatory)
- ✓Fuel quantity, time and date added (with mileage)
- ✓Maintenance dates with part replacement records
- ✓Signature of tasks completed
- ✓Signature of any extra approvals for major repairs
- ✓After-task equipment inspection notes

Regular Checkups

- ✓The service intervals of the equipment minimize overall operating costs and require less downtime for service and repairs.

- ✓It is important to keep an eye on equipment's status between services and help keep it in excellent condition by solving problems.

At each full stop

- ✓ Two important operating components of an equipment are:
  - ✓ engine and tires
  - ✓ tracks and crawlers
- ✓ Its necessary to check that :
  - ✓ they operate reliably, efficiently and safely.
  - ✓ it's a good idea to check engine oil and wear levels of tires, tracks and crawlers at every fuel stop, or once per week.

Once a Month

- ✓ Its important to Maintain other fluids at their proper levels.
- ✓ Consult the owner's manual for guidelines related to:
  - ✓ transmission or gearbox fluid
  - ✓ engine coolant
  - ✓ power steering fluid
  - ✓ windshield washer fluid
  - ✓ hydraulic fluid
  - ✓ clutch or brake fluid
  - ✓ Check all exterior lights and warning siren functions for operation as well, and maintain as required.

Maintaining Good Appearance:

✓Keeping equipment clean and protected inside and out will help preserving its appearance and value over time.

✓Owner's manual provides great guidance for cleaning and maintaining the various components and materials.

✓ Always use recommended cleaning materials (chemicals) or tools.

Maintenance Schedule

✓The equipment is designed to perform and last under specific maintenance conditions.

✓You can help preserve equipment by following the maintenance schedule present in the owner's manual.

✓The schedule is designed with the equipment's continued safety and top performance in mind and is one of the greatest assets to ensure long life of your vehicle.

Maintenance Schedule

Maintenance items	Service time				
	Daily	Weekly	Monthly	6 months	Yearly
Inspection	X				
Check coolant heater	X				
Check coolant level	X				
Check oil level	X				
Check fuel level	X				
Check charge-air piping	X				
Check/clean air cleaner		X			
Check battery charger		X			
Drain fuel filter		X			
Drain water from fuel tank		X			
Check coolant concentration			X		
Check drive belt tension			X		
Drain exhaust condensate			X		
Check starting batteries			X		
Change oil and filter				X	
Change coolant filter				X	
Clean crankcase breather				X	
Change air cleaner element				X	
Check radiator hoses				X	
Change fuel filters				X	
Clean cooling systems					X

Maintenance Log

✓The downloadable maintenance log provides a convenient and useful record of equipment's service history.

✓ One can keep track of the equipment's service dates and all maintenance performed on the equipment.

Equipment Maintenance Log

Make:	Komatsu
Model:	JK-XZ
Year:	2004
Vehicle ID Number:	XZDS_32456
Engine:	TJ-SS

Total Cost: 155.12

Date of Service	Mileage at Service	Work Performed and Service Schedule	Performed By	Cost	Notes
18/06/2011	8,755	Oil Change, Replace Oil Filter	Jiffy Lube	74.89	
26/03/2012	17,339	Oil Change, Replace Oil Filter General Inspection & Tire Rotation	Jiffy Lube	80.23	
07/06/2012	20,611	A/C Discharge Hose Broken Recall fix: Replace Wiper Rod Arm	Dealer	-	Covered under warranty
	30,000	Oil Change, Replace Oil Filter Air, Cabin Air Filters Tire Rotation Inspect Drive Belts			
	40,000	Oil Change, Replace Oil Filter General Inspection & Tire Rotation			
	45,000	Flush/Replace Brake Fluid			
	50,000	Oil Change, Replace Oil Filter Rotate Tires			
	60,000	Oil Change, Replace Oil Filter			

Planning for heavy equipment operations

✓Set up a preconstruction meeting inviting all contractors to discuss ways to coordinate work activities, identify potential hazards, and means to eliminate or reduce them.

✓Develop a process for reviewing incidents and close calls.

✓Identify hazards and ways to correct them.

Planning for heavy equipment operations

✓Develop diagrams to show how construction vehicles and heavy equipment will enter, move, and leave the work zone

✓Design the workspace so that backing up and blind spots are minimal

✓Establish ways to provide for well-lit work areas.

Traffic Control

✓Prevent unauthorized access to worksite.

✓Establish parking areas for workers and visitors

✓Install barricades or other barriers to clearly delineate traffic routes and prevent vehicles from coming into the work zone

Traffic Control

✓Designate a single traffic control person to authorize, monitor, and direct the movement of vehicles including backing up

✓Provide alternate routes for workers on foot to access the work area, if possible

✓Authorize the traffic control supervisor to temporarily stop work until traffic congestion is under control or eliminated

Pre-start / Walk Around Inspection

✓Check for any warning lights, if any such lights on, refer to operator's manual

✓Check for loose or worn parts and repair or replace immediately.

✓Check all fluid/coolant levels.

✓**Caution:** Open the radiator cap only when the engine is cooled.

Pre-start / Walk Around Inspection

✓hydraulic line connectors and hoses for leaks before applying pressure to the system. Use paper or cardboard, not your hands, to search for leaks.

✓**Caution:** Hydraulic fluid escaping under pressure can penetrate skin and cause serious bodily harm.

✓Check tires for cuts, bulges, irregularities, abnormal wear and proper inflation.

✓Mount a fire extinguisher and first aid kit in the cab.

Train students and young workers

✓Review with them their information on What Can Happen to You and How to Keep Yourself Safe when working around heavy construction equipment

✓Hold daily toolbox meetings at the job site to highlight potential dangers of today's tasks. Discuss close calls

✓To recognize and avoid the hazards of working on foot around vehicles and heavy construction equipment by staying away and working at safe distances

✓To recognize and stay away from the blind spots of heavy equipment and vehicles.

Train students and young workers

✓To be alert to potential hazards that may be created by another contractor's employees

✓To work within the line of sight of the equipment operator and maintain visual contact with the operator

✓To wear high visibility safety clothing including reflective gloves, arm bands, and other accessories. This is critical under poor lighting and bad weather conditions

Work Safer

✓Schedule work tasks to keep workers on foot out of areas where heavy equipment and construction vehicles are present whenever possible

✓Use sensing units on heavy equipment to detect workers on foot

✓Encourage communication, e.g., hand signals, two way radios for employees assigned to watch for safety in the work zone or employees on foot talking to the equipment operator

✓Ensure backup alarms, horns on construction equipment are tested daily and function effectively. Instruct equipment operators to use these devices to call the attention of workers on foot

Work Safer

✓Encourage operators of heavy equipment and construction vehicles to:

✓move equipment only after positive visual contact (seeing each other`s eyes) has been made and confirmed with workers on foot

✓always observe jobsite speed limits and reduce speed when workers on foot are nearby

Shut Down and Parking

✓Always Park at the designated place on a level ground.

✓When parking on an inclined surface, position at right angles to the slope, block the wheels and set the parking brakes.

✓When parking, lower all loader, buckets and hydraulics to the ground.

Housekeeping

- Ensure the cab area is clean and free of debris and tools.
- Clean windshield, mirrors and lights.
- Remove all oil, grease, mud or snow from grab irons, hand rails, steps, pedal sand floor to prevent slips and falls.
- Remove or secure any loose items such as tools, chains or lunch boxes from the cab.

Heavy Equipment Selection Process

And for each type the methodology used to analyze the different criteria was based in:

1. Measuring the performance
2. Measuring the minimal risk
3. Measuring the minimal impact or environmental aspect

Heavy Equipment Selection Process

Steps of the selection methodology

CRITERIA	USED METHOD TO ANALYSE IT
Optimum performance	Minimal hourly cost Maximum hourly productivity
Minimal risk	The minimal risk criteria, will be the result from the sum of all the present risks. The valuation of these risks was made through the method proposed by the INSHT. (Instituto Nacional de Seguridad e Higiene del Trabajo).
Minimal impact or environmental aspect	The minimal impact or environmental aspect, will be the result from the sum of all the present impacts. The valuation of these impacts was made through the method of identification and evaluation of environmental impact and aspects based on the Environmental Management Systems contained in the ISO 14001 standard.

Heavy Equipment Selection Process

OPTIMUM PERFORMANCE

1. Measuring the productivity for each of the different types of equipment
2. Hourly costs
3. Factor that influence the performance of construction equipment

a. Routine delays
b. Restrictions to optimal mechanic operation
c. Site conditions
d. Direction and Supervision

Heavy Equipment Selection Process

Equipment Risk Valuation

		Severity		
		LIGHT	HAZARDOUS	EXTREMELY HAZARDOUS
		1	2	6
Low probability	1	Trivial risk 1	Tolerable risk 2	Moderate risk 6
Medium probability	2	Tolerable risk 2	Moderate risk 4 ≈ 6	Important risk 12
High probability	6	Moderate risk 6	Important risk 12	Intolerable risk 36

Heavy Equipment Selection Process

Minimum Risk Criteria

The minimal risk criteria is obtained as follows:

- ✓ Identify and evaluate all the present risks of the equipment, according to the general process of risk evaluation.
- ✓ Valuation of the found risks, by a numeric scale.
- ✓ Finally all the values for each equipment are summed which gives the value of the minimal risk criteria

Heavy Equipment Selection Process

✓ Minimal impact or Environmental Criteria

The minimal impact or environmental impact of construction equipment is obtained as follows:

1. Identification and evaluation of all impacts present on a given equipment applying a descriptive method based on the criteria of an EMS as the ISO standards.
2. Valuation of the encountered impacts according to their criticality.
3. The sum of all the values of specific equipment, this result gives the "minimal impact or environmental aspect

Troubleshooting

Lets get some basics right !

- ✓Having correct level of all fluids as required by the manual
- ✓Cleaning the air filters as per manual
- ✓Changing the air filters as required by the manual
- ✓Changing the lubrication oil when required by the manual (correct grade !)
- ✓Changing the lubrication oil filter (buy good quality and correct parts)

Lets get some basics right !

- ✓Cleaning or replacing the fuel filter as require in the manual
- ✓Correct tension for the belts, not too tight or too loose
- ✓Inspecting and changing brake pads
- ✓Inspecting and replacing tires

Lubrication Oil, your Machines's lifeline

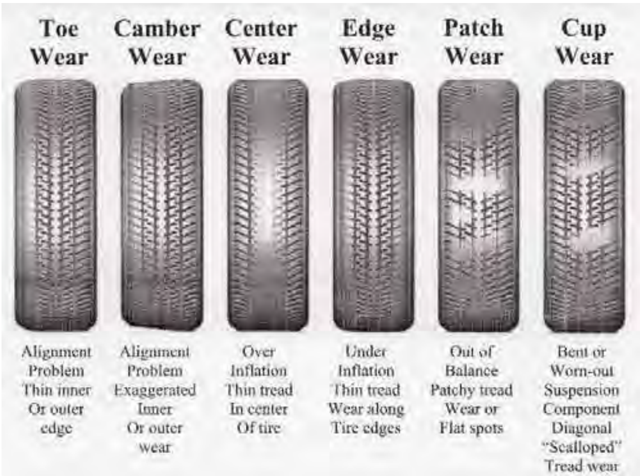
- The most important issue in your equipment's life is selecting the correct oil and changing it regularly.

Lubrication Oil Selection

- **10W40**: The "W" **means** winter. 10 is the thickness rating and is how thick it is at 0 degrees F. The larger the number, the thicker the oil. So 40 is how thick the oil is when the engine is at operating temperature. Yes the oil is THICKER when the engine is hot.

http://www.viscopedia.com/viscosity-tables/substances/sae-viscosity-grades/

Tires and breaks are your lifeline !



- ✓ **Worn out tires are safety hazard**
- ✓ **Proper tire inflation is important for good traction, fuel economy, breaking distance and tire life**

Tire size and pressure

Tire Size	Tire Load Limit and Cold Inflation Pressures			
	Single		Dual	
	Lb.	PSI	Lb.	PSI
215/85R 16E	2,680	80	2,470	80

Break Inspection!

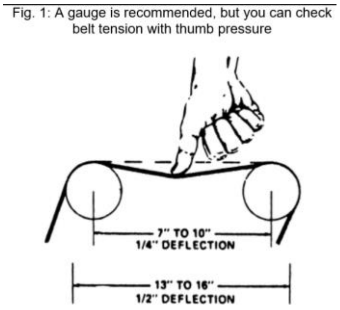
- ✓ Worn out pads are safety hazard
- ✓ changing pads on time can save rotors

Belts drive your operations !

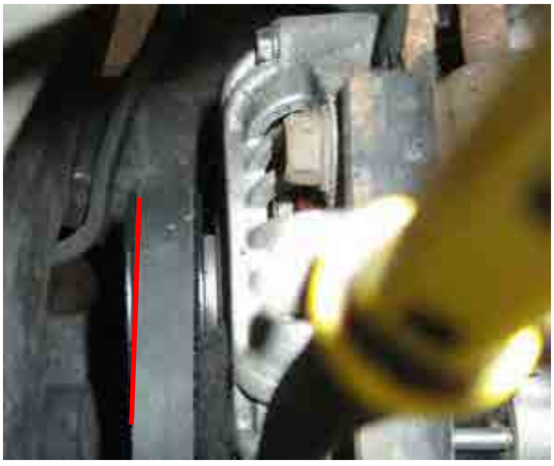
Worn-out belts

Always buy correct type!

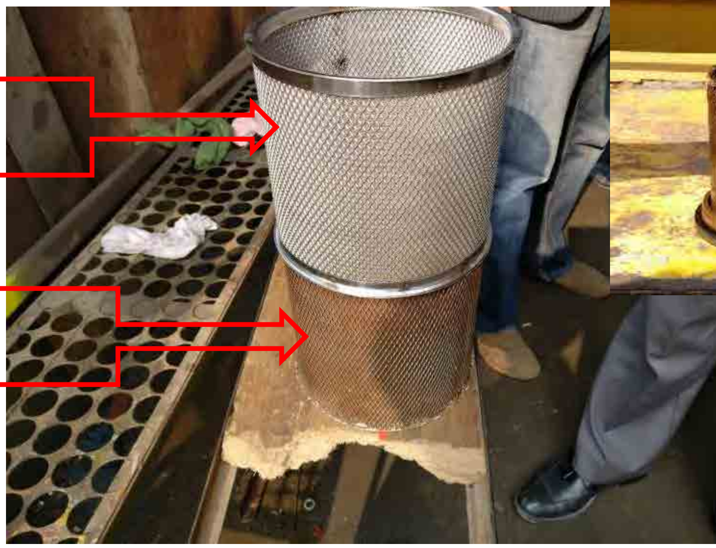
Drive belt tension adjustment



Belt alignment



Filters are lungs for your machines!



Clean Filter

Dirty Filter

Dirty Y Strainer filter

WSD 5231, Mod. 3

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Lessons from OJT

WSD 5231, Mod. 3

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Lessons from OJT

Lessons from OJT

Lessons from OJT

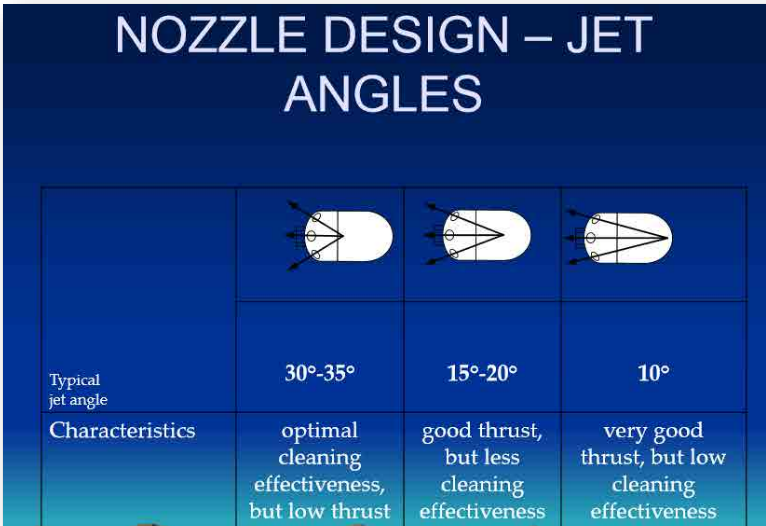
Steel Lower Manhole Guide Shoe

Lower Manhole Hose Guide Roller-Grabber

Lessons from OJT

- ✓**Correct Material**
- ✓**Lasts longer**
- ✓**Better efficiency**

Lessons from OJT



Wrap-up

Things to take home…

1. Heavy machines drive your operations
2. Always do a root cause analysis
3. Repair is not preventive maintenance
4. Use standard parts and fluids
5. Keep records, always !!!

O & M of Mechanical Equipment
WSD 5231

Water Meter Introduction and Selection

Module 4

Agenda

- ✓ Ice Breaker and Class Introduction
- ✓ Resources and handouts
- ✓ Importance of water meters
- ✓ Types of water meters

Agenda

✓ Selection of water meters

✓ Installation of water meters

✓ Maintenance of water meters

Icebreaker and class introduction

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

Icebreaker and Class Introduction

Now it is your turn…

- Degree and backgrounds?
- Share your work experience relative to water meter selection,isntallation & maintenance?

Icebreaker and Class Introduction

Now it is your turn…

- Any prior experience related to water metering?
- Why interested in this module?
- What best skills do you bring to the class?

Resources and Handouts

•Lecture notes

•Water meter installation guidelines

•Metering in municipalities - WRC report

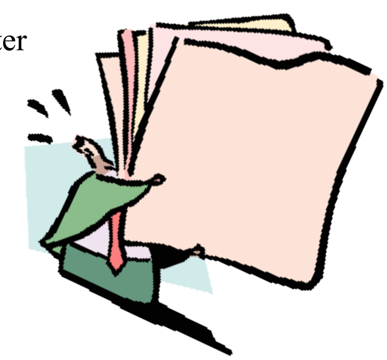
•Water meters (various types)

•Water meter major components

Resources and Handouts

•Introduction to Integrated Water Meter Management, Zyl,J. (2011)

•Water meters, Vol.4, Satterfield, Z. (2004)



Water meter overview

- ✓ Water metering is the process of measuring water use.
- ✓ And, the best way for a water utility to measure or account for the water produced and then sold is by using water meters.

WSD 5321, Mod 4 9

Importance of water meters

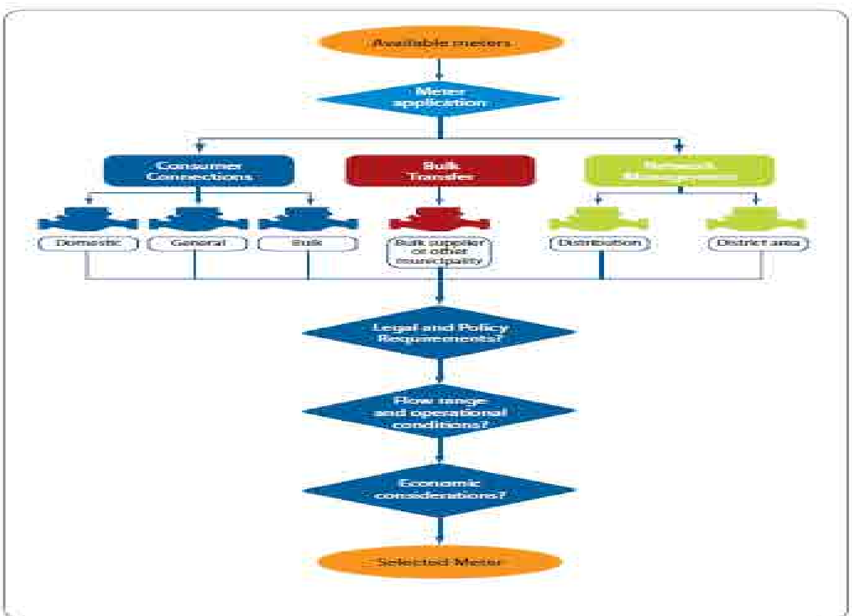
- ✓ Water meters are important to a utility for several reasons:
- ✓ Helps in monitoring the volume of finished water
- ✓ Help in water conservation
- ✓ allow the system to demonstrate accountability

WSD 5321, Mod 4 10

Importance of water meters

- ✓ fair for all customers because they record specific usage
- ✓ aid in the detection of leaks and waterline breaks in the distribution system.
- ✓ monitor the volume of consumed water

Water Meter Selection Process Flow Chart



Meter application

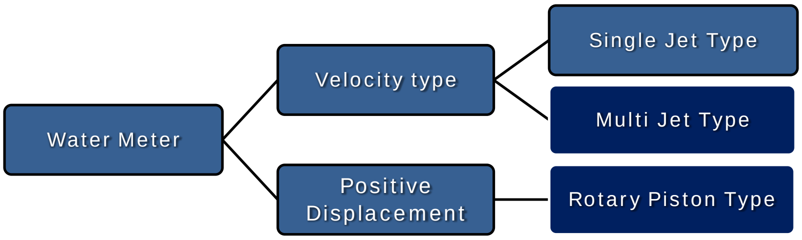
- ✓ Purpose
- ✓ There are three major applications of water meters:

1. Consumer meters
2. Bulk transfer meters
3. Management meters

Management meters

- ✓ Management meters measure the distribution of water to different parts of the network.
- ✓ They are essential for many technical and management functions.
- ✓ Management meters that are not district area meters are collectively called distribution meters.

Major Water Meter Types in WASA (Consumer Meters)



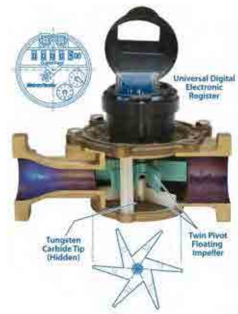
Dry type & Wet type

- The dry type water meter has the reading mechanism hermetically separated from the water flow chamber.
- The transmission to the reading mechanism gears takes place via magnetic coupling between the turbine and the reading mechanism itself.
- The wet type water meters has the reading mechanism the reading mechanism completely immersed in the water and the transmission is direct from the turbine to the gears of the mechanism itself.

Single Jet Type

- The principle of operation is given by the incidence of a single tangential stream of water with a turbine mounted in a radial position within the body of the meter.

- The rotation of the turbine transmits the motion to the reading mechanism allowing the measurement of the volume of water passing through the meter.



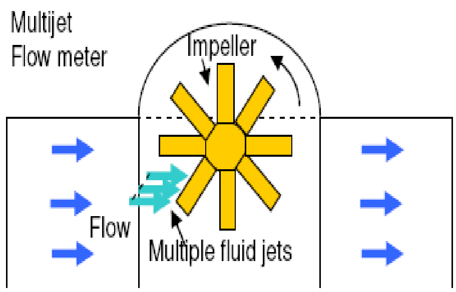
Multi Jet Type

- The principle of operation is to force the passage of the inlet water flow through a series of ducts open in a capsule, called distributor, containing the turbine.

- The entrance of the water through the ducts generates a series of symmetrical jets that impact the turbine keeping it in perfect balance.

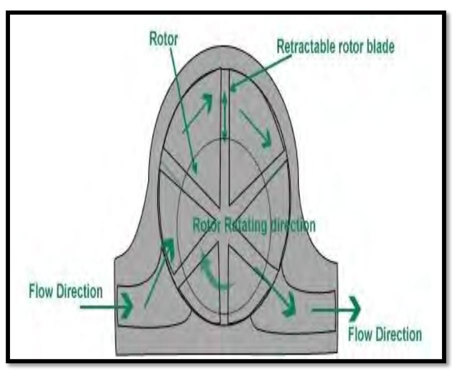
Multi-jet meters

- ✓ They have tangential openings in a chamber to direct the water flow across a rotor with many vanes.



Piston meters

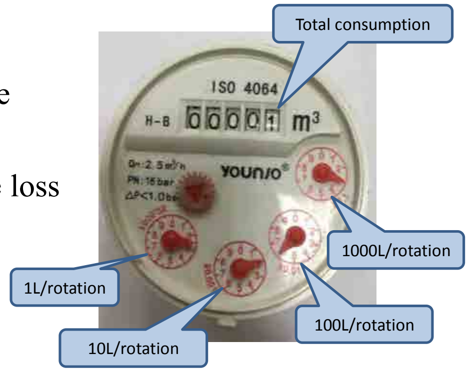
- ✓ They have a piston that oscillates back and forth as water flows through the meter.



Oscillating piston meter

Display of Water Meter

- ISO 4064: 1993
  - Qn : Nominal Flow Rate
  - PN : Nominal pressure
  - △P : maximum pressure loss



Selection Parameters (Consumer Meters)

ISO 4064 :1993

Type	Nominal Dia	Qn [m3/h]	Qmax [m3/h]
Velocity type	13	1.5	3
	20	2.5	5
	25	3	6

Qn : Nominal Flow Rate
Qt : Transitional Flow Rate
Class B_0.08 × Qn Class C 0.015 × Qn
Qmin : Minimum Flow Rate
Class B _0.02 × Qn Class C_0.01 × Qn
Qmax : Maximum Flow Rate
Class B _2 × Qn Class C_2 × Qn

R : Qmax/Qmin
Class B : R=50
Class C : R=100

Other Selection Parameters

- **Material:**

e.g.: All materials in contact with the water passing through the water meter shall be made of materials which are harmless, non-contaminating and biologically inert.

- **Pressure test:**

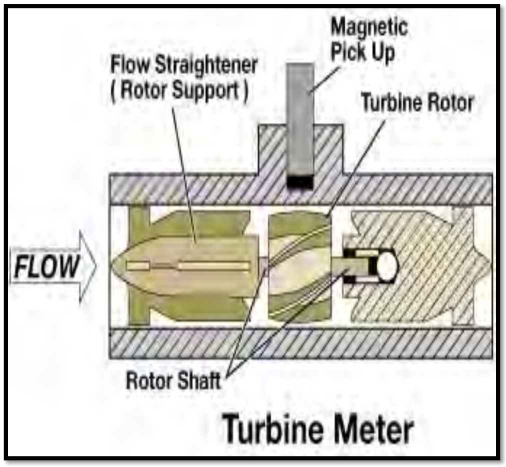
e.g.: The water meter shall conform to the pressure resistance performance.

Comparison of water meters

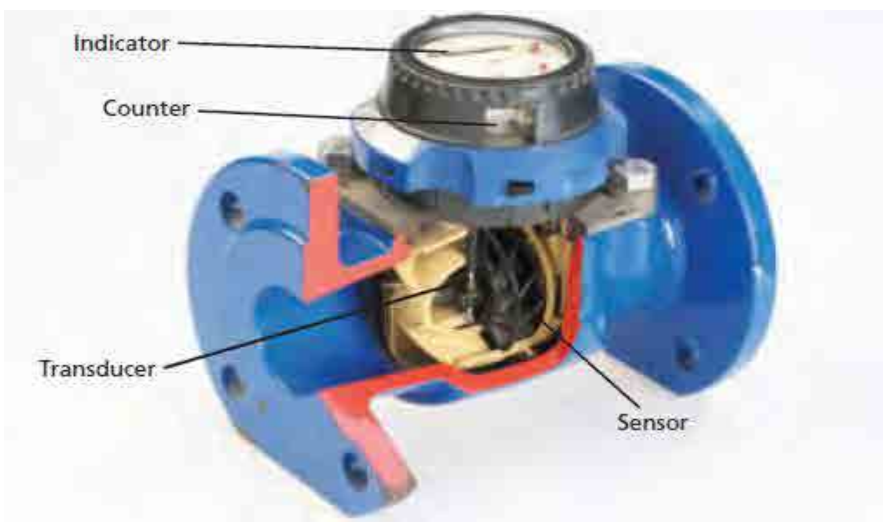
	Single jet (dry)	Multi jet (wet)	Rotary piston (wet)
Appearance			
Measuring method	Velocity	Velocity	Positive displacement
Structure	Simple structure	Complicated than Single jet	Complicated than others
Cost	Inexpensive	Inexpensive	More expensive than others
Others	Highly reliable operation	Small amount of water can be accumulated accurately	High accuracy than others

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.



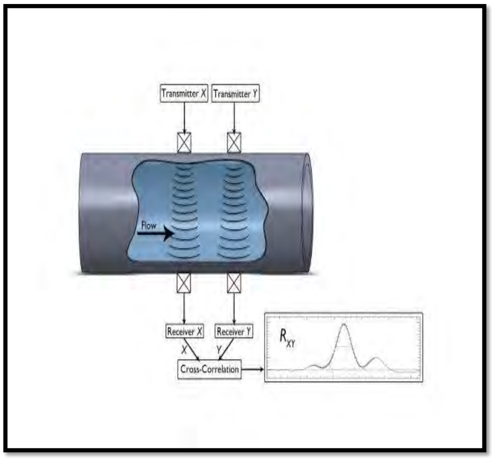
Section through a flow meter showing the sensor, transducer, counter and indicator (meter supplied by Sensus)



Ultrasonic meters

- ✓ They work by sending sound waves diagonally across the flow of water in the pipe.

- ✓ Changes in the velocity of water are converted electronically to change in flow rate.



Ultrasonic meter

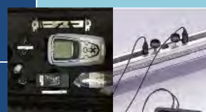
Magnetic meter

- ✓ They have an insulated sec through which water flows.

- ✓ The flow of water induce: electrical current that proportional to the velocity hence the flow rate.

Magnetic water meter

Comparison of Flow meters

	Ultra Sonic	Electromagnetic	Turbine
Appearance			
Accuracy	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

Water meter installation

- ✓ Its important to install a meter in right spot
- ✓ In case of a private water service i.e.:

i. inside the front property boundary (inlet riser: b/w 300mm & 1000mm)

ii. from the left or right property boundary (inlet riser: b/w 300 & 600mm).

iii. and outlet riser are 300 mm from the ground

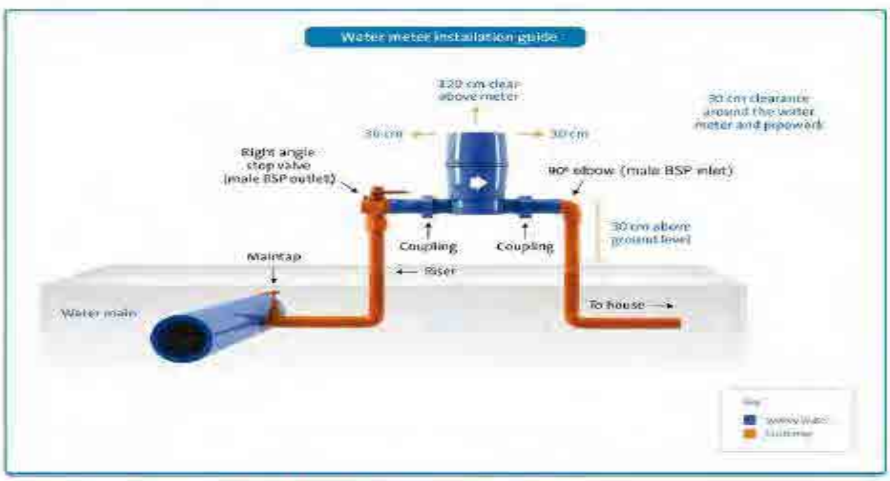
iv. and outlet riser are parallel to the closest side boundary

Water meter installation

- ✓ If you're installing meters close together, you must allow 300 mm between them.
- ✓ You must not install the meter
- ✓ more than 1.5 metres above the ground

Spacing required in installation

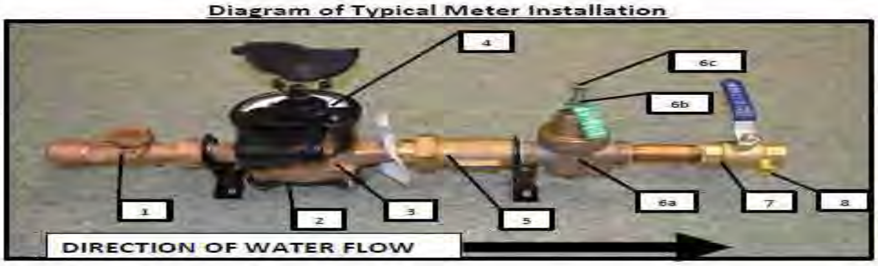
20 mm to 50 mm light duty meters



If you're installing a meter, doing it this way will help us access them.

Water Meter Installation Schematic for cold environments (source: Lambton Shores municipality)

Diagram of Typical Meter Installation



#	Meter Assembly Component
1.	Isolation Valve (attached to waterline from street)
2.	Water Meter Frost Plate (sacrificial black steel, under meter, will break if frozen)
3.	Water Meter Base
4.	Water Meter Register Head
5.	Dual Check Backflow Preventer (DuC)
6a.	Pressure Reducing Valve (PRV)
6b.	Pressure Reducing Valve Lock Nut (hexagonal nut)
6c.	Pressure Reducing Valve Operating Bolt (threaded bolt with hexagon head)
7.	Residential Isolation Valve (connects to household plumbing)
8.	Drain Port (for winterizing plumbing) (not included in a pit meter assembly)

These are the generic components to a water meter assembly in Lambton Shores. There are variations of older style valves but all operate similarly.

Water meter maintenance

- ✓ Proper maintenance of metering device is essential for its operation.
- ✓ A municipality should develop a water meter maintenance programme.
- ✓ Water meter maintenance requires actions, such as cleaning of strainers, cleaning and repair of meter boxes, fixing leaks, register covers.

Inspection Checklist

- ✓ A checklist should be developed for use by meter inspectors in the field. This checklist should include the following information:
  - ✓ Location and date.
  - ✓ Inspector's name.
  - ✓ Meter identification: make, model, size, serial number and current reading.
  - ✓ Condition of meter installation: meter body, meter register, pipe work, leakage, upstream valve, downstream valve, meter chamber, strainer, signs of unauthorised connections and other.
  - ✓ Actions taken: strainer cleaned/replaced, meter mechanism inspected and/or valve operation checked.
  - ✓ Action required: cleaning, chamber repairs, meter test and/or leak repairs.

Problems related to metering

- ✓ Suspended solids get stuck in it & causes meters damaging.
- ✓ Meters buried under soil and vegetation
- ✓ Due to high TDS (total suspended solids) lime or metal oxide deposits in meters.
- ✓ Consumer complaints of suspected meter errors

Meter almost buried in the soil

Problems related to metering

- ✓ Leakage from meter connections.
- ✓ Damage to meters due to high velocity air flow when drained pipes are refilled.
- ✓ Vandalism to meters for scrap metal or in anger, often in 'retaliation' when indigent consumers are cut off

Leakages from meter connections

Problems related to monitoring

- ✓ Strainers to get clogged. These solids enter the system most often due to:
  - ✓Large pipe bursts.
  - ✓Mineral
  - ✓Corrosion
  - ✓Inadequate water treatment or malfunctioning treatment plants.

Pipe leakages causes the system to get clogged