Annex 3.22
Training Material for O&M of Electrical Equipment
in Fall 2016

O & M of Mechanical and Electrical Equipment
WSD 5231

Electrical Panel and Instrumentation Equipment

Module 2-Lecture 1

ALJAZARI ACADEMY

O & M of Mechanical and Electrical Equipment (Team)

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

ALJAZARI ACADEMY

Water and Sanitation Agency, Lahore

Course Dates

Modules	Dates	Themes
Module 2	From 23rd November to 25th November, 2016	Electrical Control Panels
Module 3	From 30th November to 2nd December, 2016	Generators
Module 6	From 7th December to 9th December, 2016	Introduction To SCADA & HSE

ALJAZARI ACADEMY

Water and Sanitation Agency, Lahore

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

5/22

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

6/22

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

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?

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?

9/22

Agenda

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

10/22

Agenda

- ✓ Motor Starters
- ✓ Power factor correction
- ✓ Standard Operation Procedure (SOP)
- ✓ Preventive Maintenance and Record Keeping

11/22

Class Evaluation Structure

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

12/22

Introduction to Current & Voltage

13/22

Lecture Goals

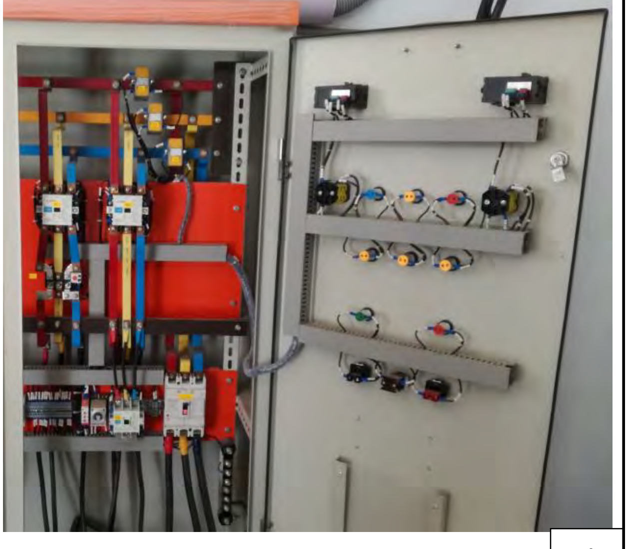
- **Distinguish types of panels in electrical systems of WASAs**
- **Understanding of basic sequence of the panel**

14/22

Electrical Control Panel

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.



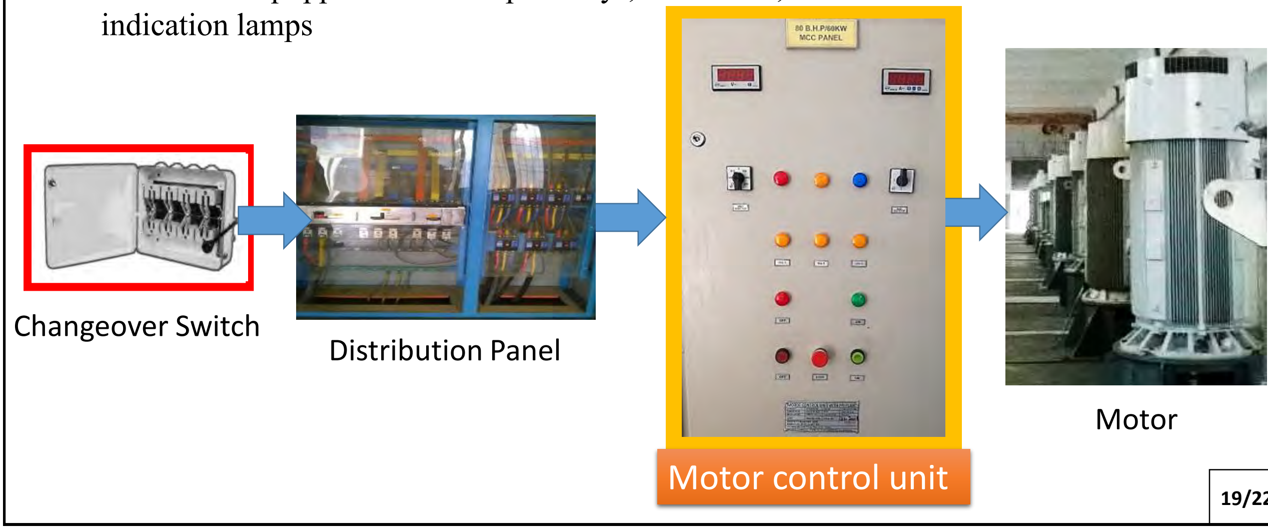
Major types of electrical control panel used in WASAs

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

Which one?

1.Motor control unit (MCU)

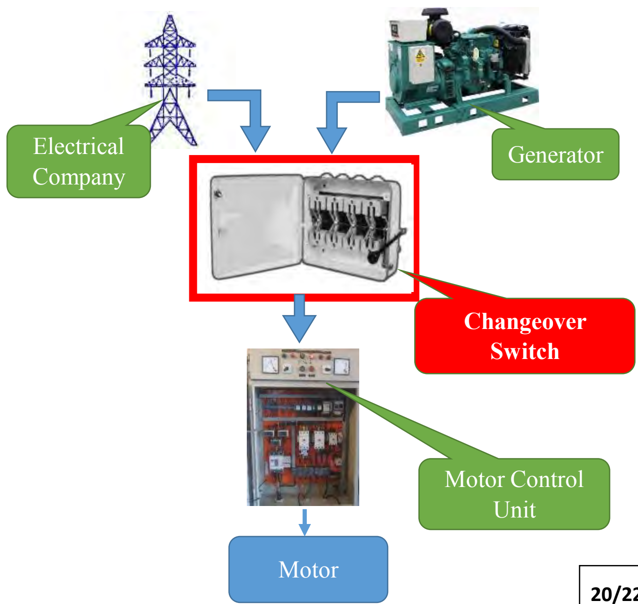
Motor Control Unit or simply MCU, are used to control and protect the electric motor. It is equipped with multiple relays, contactors, connections and indication lamps



19/22

2.Changeover switch or Panel

- ✓ 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



20/22

3.Power factor improvement panel

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

21/22

4.Electrical distribution panel

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

22/22

Introduction to Panel Components

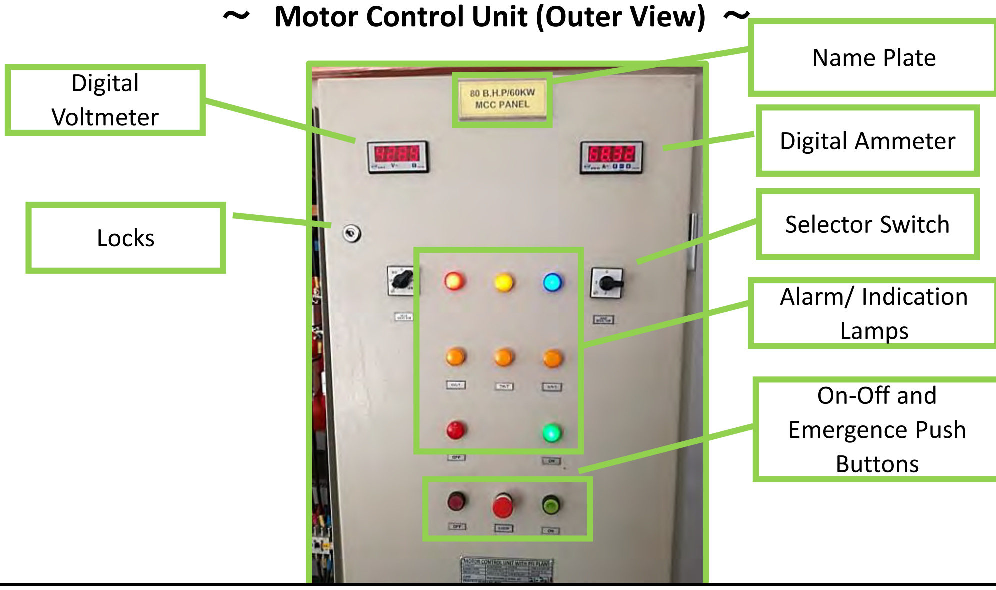
Goal

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

What are these?

Components of Electrical Control Panel

~ Motor Control Unit (Outer View) ~



Selector Switches

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

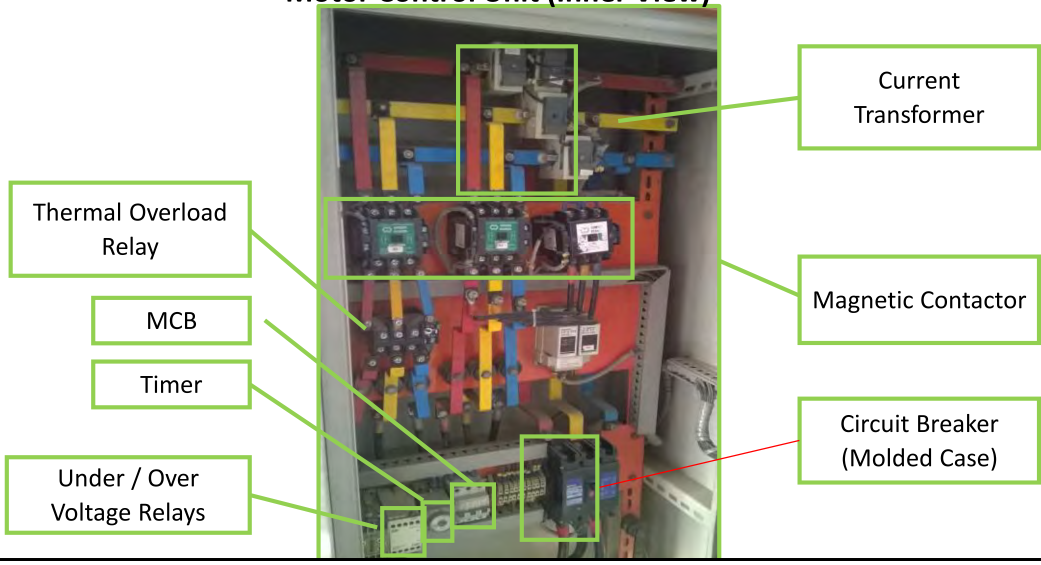
Ampere & Voltmeter meter

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

Zero Adjustment

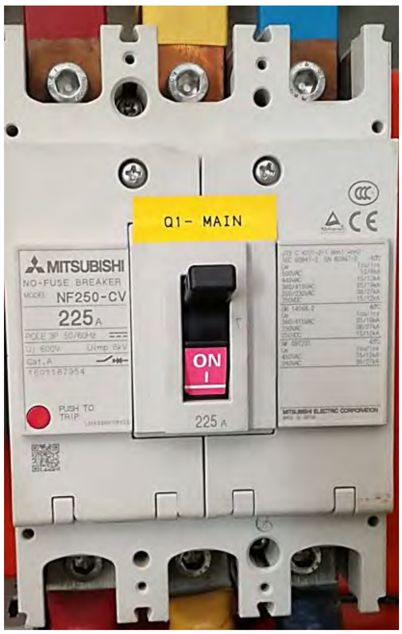
Components of Electrical Control Panel

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



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.

Protective Relays

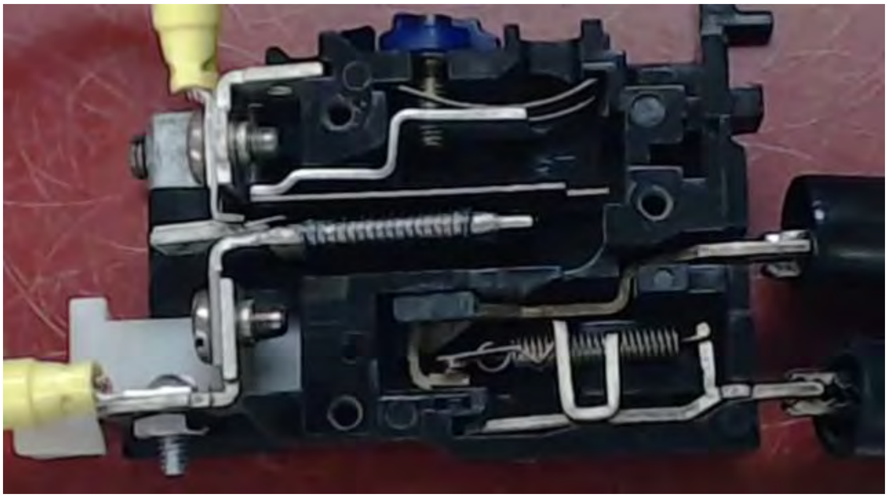
✓ Protective relays detect electrical faults, isolate the faults from system and activate alarms is a faulty condition sensed

Thermal Relay

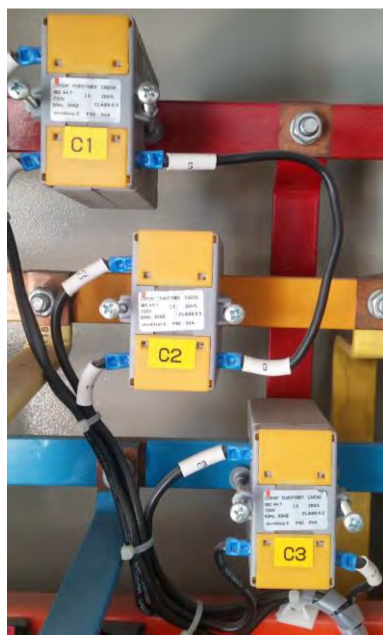
Under/Over Voltage Relay

Phase Failure Relay

Operation of thermal relay



5. Current transformers (CT)



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

6. Timer

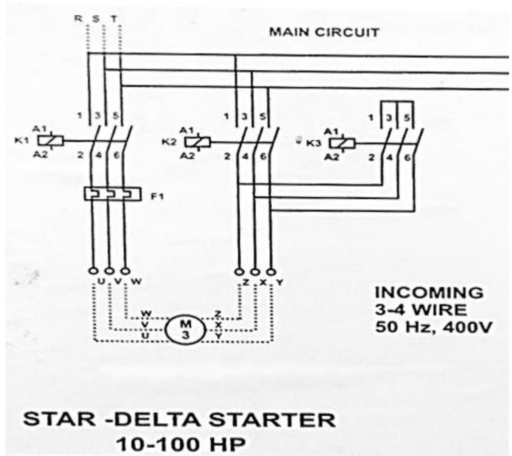
✓ Use to convert the motor connections from Star to Delta after specific time

WIRING DIAGRAMS

Wiring Diagram

✓ Shows how the components are connected

✓ It should be always available at the site



Basic Concept of Connection

WAPDA

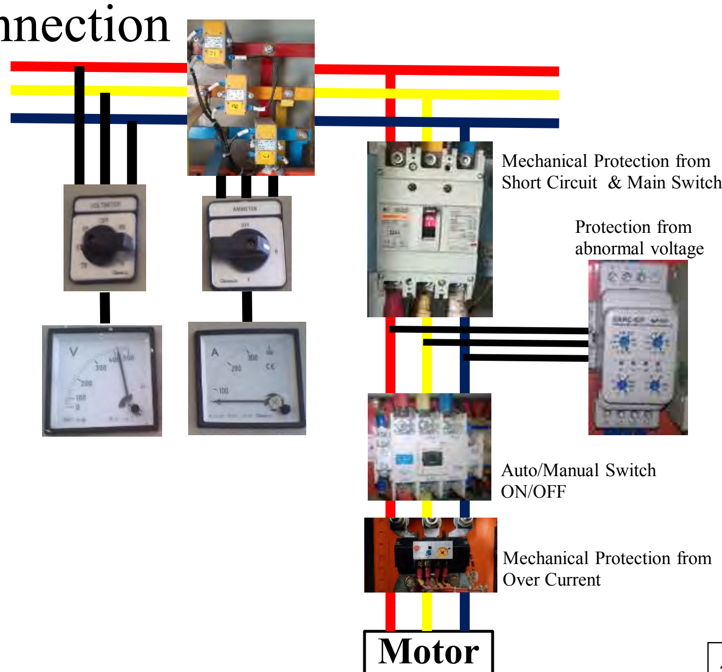
3 phase, 400V

Basic Power Circuit for Motor in WASA

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

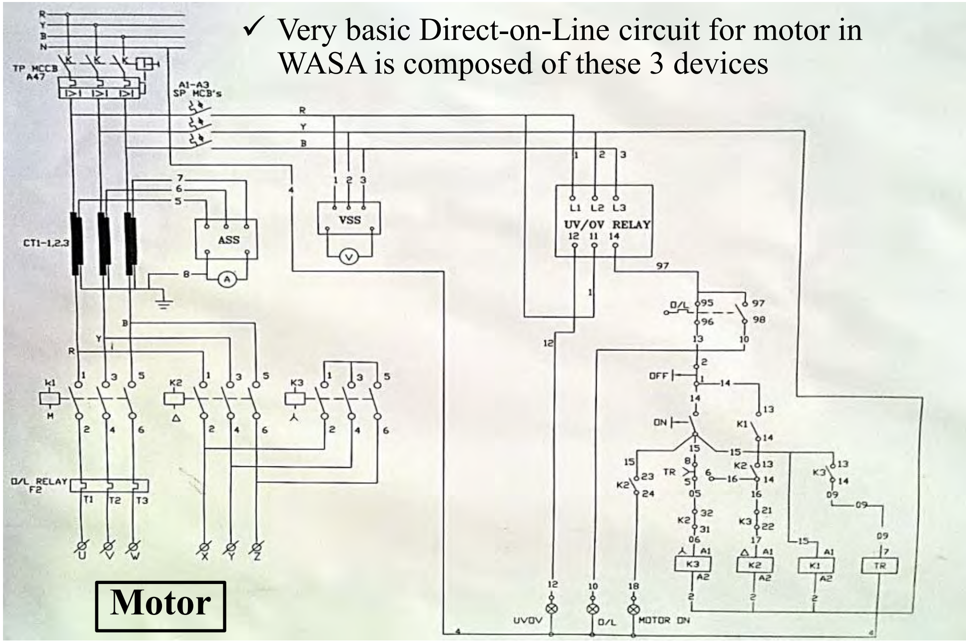
Monitoring Device

- Voltage Meter
- Ampere Meter



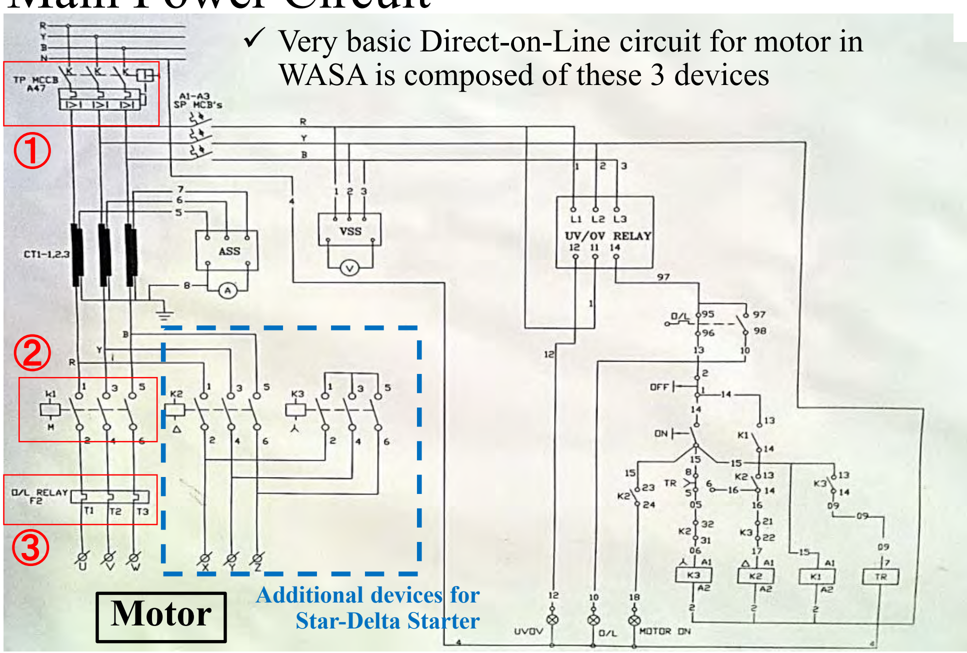
Main Power Circuit

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



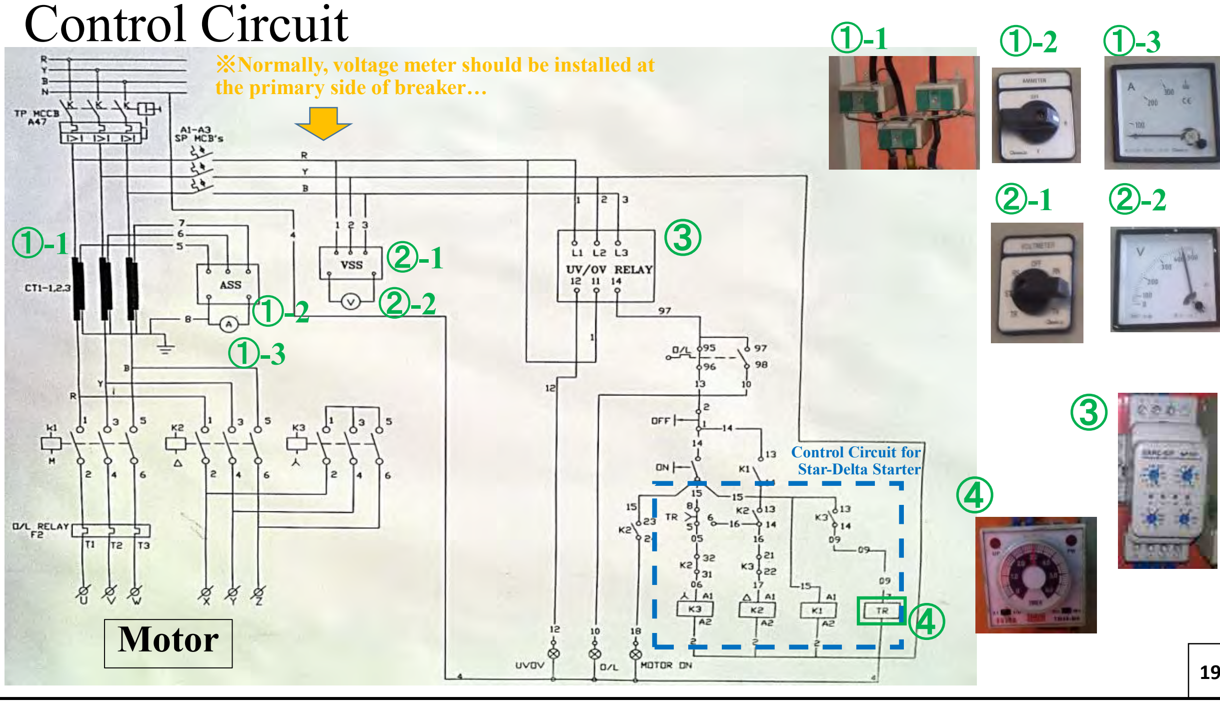
Main Power Circuit

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



Basic Power Circuit for Motor

Control Circuit



ACTIVITY – 1

Complete the wiring diagram with the suitable components

Motor Starters & Power Factor Improvement

1/18

Goal of this Lecture

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

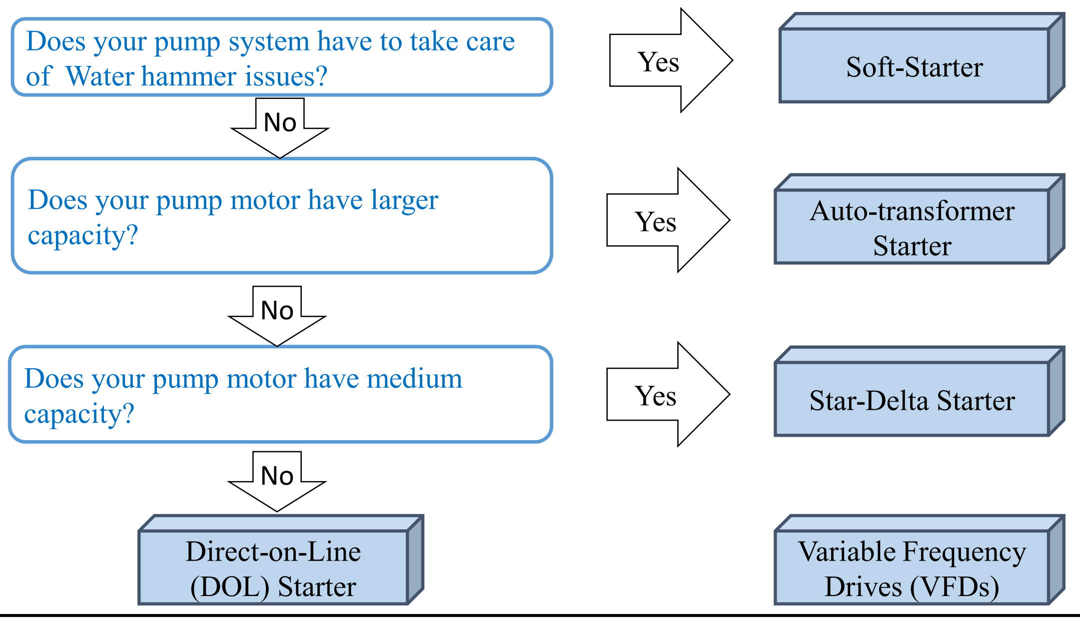
2/18

Motor Starters

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

3/18

Selection of Motor Starter



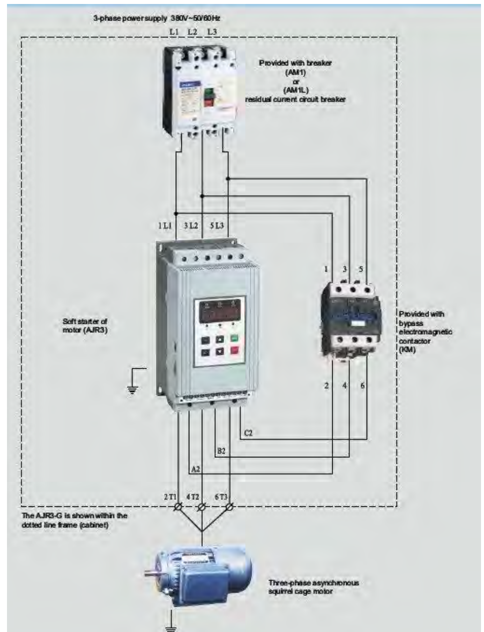
4/18

Soft Starter

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

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

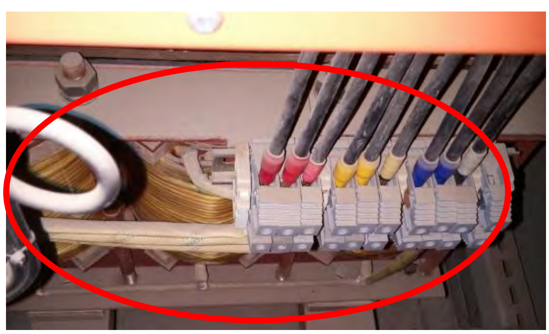
Disadvantage:
Electronic device shall be installed in a good environment so extra care is required



Single Line Diagram of Soft Starter

Auto-transformer Starter

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

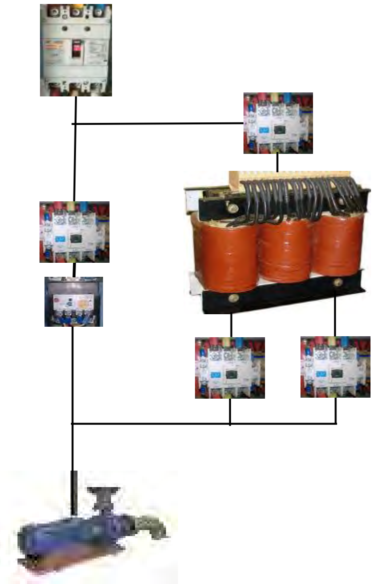


Transformer

Auto-transformer Starter

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

Disadvantage:
Expensive and wider space for installation is required



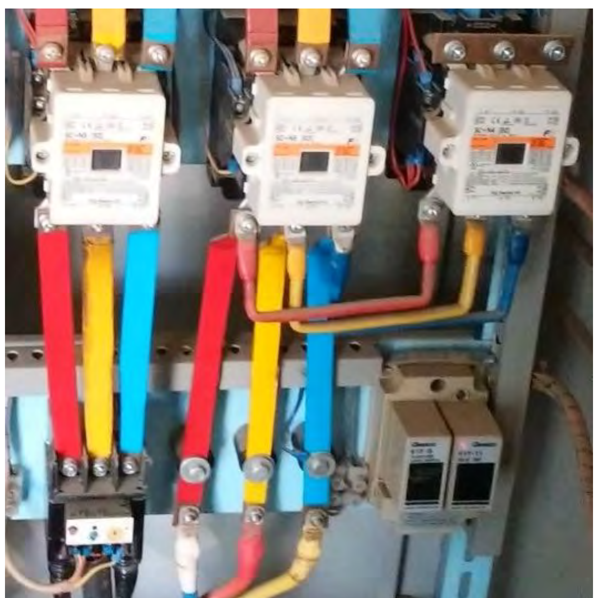
Single Line Diagram of Auto-transformer starter

7/18

Star-Delta Starter

Function:

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

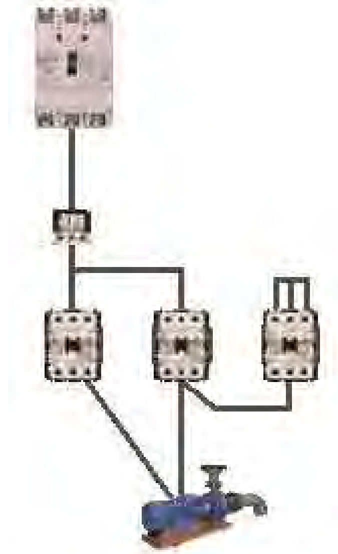


8/18

Star-Delta Starter

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

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



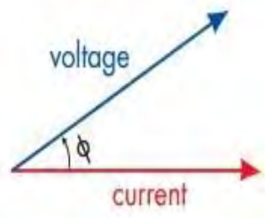
Single Line Diagram of Star-Delta Starter

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).

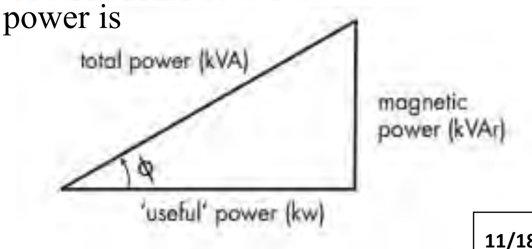


Phaser diagram of voltage and current

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

✓ It is a measure of how efficiently electrical power is converted into useful work output.

✓ The ideal power factor is unity.



Power Factor Explained

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.

Power Factor Improvement Panel

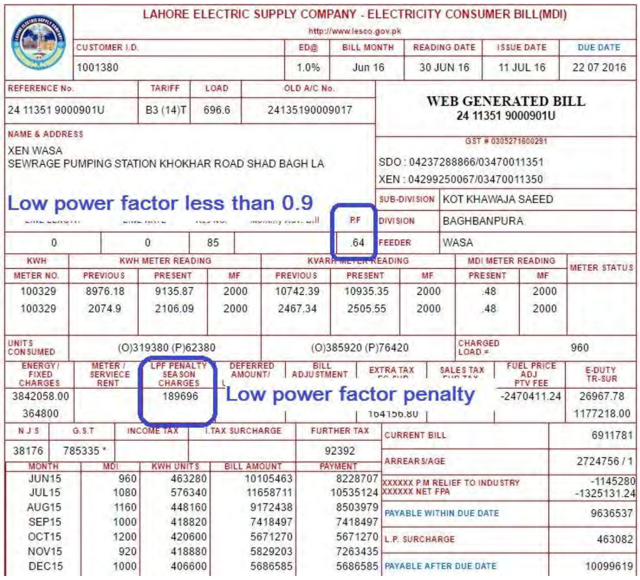
Auto Power Factor Controller

- ✓ 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

SUB-DIVISION	KOT KHAWAJA SAEED
DIVISION	BAGHBANPURA
FEEDER	WASA

Low power factor less than 0.9

				P.F
0	0	85		.64

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

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

ENERGY / FIXED CHARGES	METER / 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	-1145280
XXXXXX NET FPA	-1325131.24
PAYABLE WITHIN DUE DATE	9636537
L.P. SURCHARGE	463082
PAYABLE AFTER DUE DATE	10099619

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.

STANDARD OPERATING PROCEDURE (SOP)

Goal of Lecture

- **Get the skill to perform Standard Operating Procedures on MCU**

Standard Operating Procedure (SOP)

✓Before turning on the motor, values of all protective relays must be checked once a day

Check List of Standard Operation Procedure for Electrical Facility

Approved by :

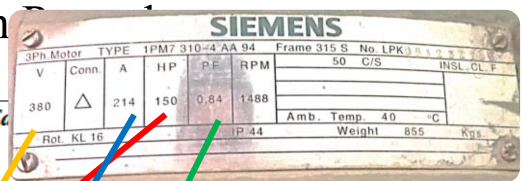
Inspected by : 1. 2.

Evaluation Criteria

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

Code	Site/Pump Name	Inspection Date	Motor Specification					Inspection Items for Electrical Panel Condition													
								Document			Visual (Outside)			Visual (Inside)			Operation		Settings		
			Rated Capacity	Rated Voltage	Rated Ampere	Efficiency	Power Factor	Operation Record	Drawings	Vender Manual	Indications of Lamp/Switch	Status/Fualt Indication Lamps	Voltage /Ampere Meter	Cleanliness	Intrusion Path	Bypass-Circuit	How to operate changeover switch	Frequency of Start/Stop	Over/Under Voltage Relay	Over Current (Tharmal) Relay	Y-Δ Timer
			(kW)	(V)	(A)	-	-	Compare with the sample	Pump installation , electrical line ddiagram	Pump/Panel devices	all lamps/switches have name tag	all lamps are visibly bright enough	Proper functioning and zero adjustment	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	±10% of rated voltage of motor	Equall or less than rated current of motor	Not less than 2 seconds

Check List for Standard Operation



Check List of Standard Operation Procedure for Electrical Fa

Approved by : SDO

Inspected by : 1. Sub Engineer (Electrical) **2.**

Code	Site/Pump Name	Inspection Date	Motor Specification				
			Rated Capacity	Rated Voltage	Rated Ampere	Efficiency	Power Factor
			(kW)	(V)	(A)	-	-
XYZ 123	Tube well 103	12-DEC-16	150 HP x 0.746 = 112KW	380	214	–	0.84

Check List for Facility Inspection

Evaluation Criteria

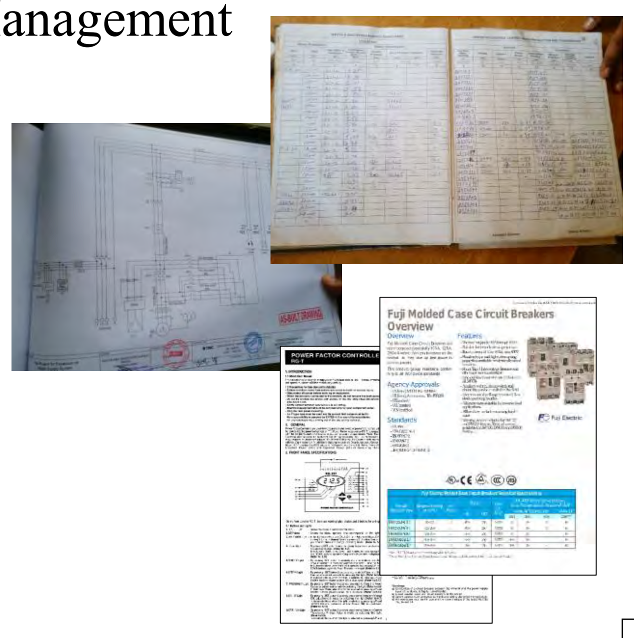
✓ : Good　　　　　　× : No care at all or need to be newly installed

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

Inspection Items for Electrical Panel Condition

Document			Visual (Outside)			Visual (Inside)			Operation		Settings		
Operation Record	Drawings	Vender Manual	Indications of Lamp/Switch	Status/Fualt Indication Lamps	Voltage /Ampere Meter	Cleanliness	Intrusion Path	Bypass-Circuit	How to operate changeover switch	Frequency of Start/Stop	Over/Under Voltage Relay	Over Current (Tharmal) Relay	Y-Δ Timer
Compare with the sample	Pump installation , electrical line ddiagram	Pump/Panel devices	all lamps/switches have name tag	all lamps are visibly bright enough	Proper functioning and zero adjustment	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	± 10% of rated voltage of motor	Equall or less than rated current of motor	Not less than 2 seconds

Basic Documentation Management



- ✓ Operation & Maintenance 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.

Check List for Facility Inspection

Evaluation Criteria

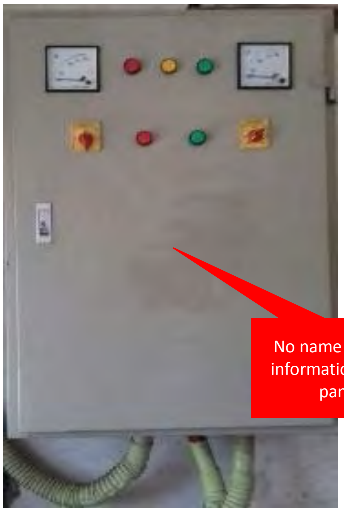
✓ : Good ×: No care at all or need to be newly installed

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

Inspection Items for Electrical Panel Condition													
Document			Visual (Outside)			Visual (Inside)			Operation		Settings		
Operation Record	Drawings	Vender Manual	Indications of Lamp/Switch	Status/Fualt Indication Lamps	Voltage /Ampere Meter	Cleanliness	Intrusion Path	Bypass-Circuit	How to operate changeover switch	Frequency of Start/Stop	Over/Under Voltage Relay	Over Current (Tharmal) Relay	Y-Δ Timer
Compare with the sample	Pump installation , electrical line ddiagram	Pump/Panel devices	all lamps/switches have name tag	all lamps are visibly bright enough	Proper functioning and zero adjustment	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	±10% of rated voltage of motor	Equall or less than rated current of motor	Not less than 2 seconds

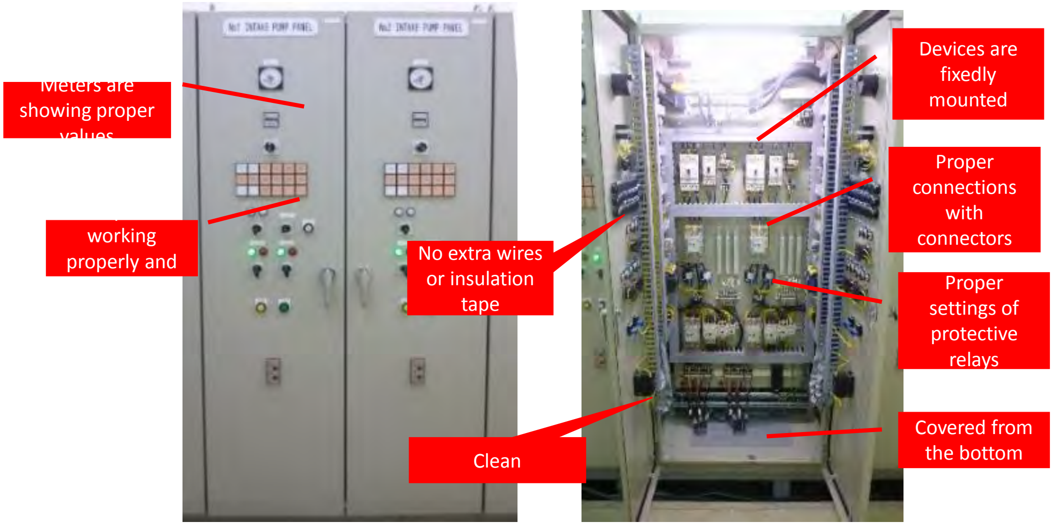
Comparison of the Panel Conditions

NEED TO BE IMPROVED



Comparison of the Panel Conditions

IDEAL CONDITION OF A PANEL



Check List for Facility Inspection

Evaluation Criteria

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

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

Inspection Items for Electrical Panel Condition													
Document			Visual (Outside)			Visual (Inside)			Operation		Settings		
Operation Record	Drawings	Vender Manual	Indications of Lamp/Switch	Status/Fualt Indication Lamps	Voltage /Ampere Meter	Cleanliness	Intrusion Path	Bypass-Circuit	How to operate changeover switch	Frequency of Start/Stop	Over/Under Voltage Relay	Over Current (Tharmal) Relay	Y-Δ Timer
Compare with the sample	Pump installation , electrical line ddiagram	Pump/Panel devices	all lamps/switches have name tag	all lamps are visibly bright enough	Proper functioning and zero adjustment	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	±10% of rated voltage of motor	Equall or less than rated current of motor	Not less than 2 seconds

Difference between…

Disconnection Switch

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

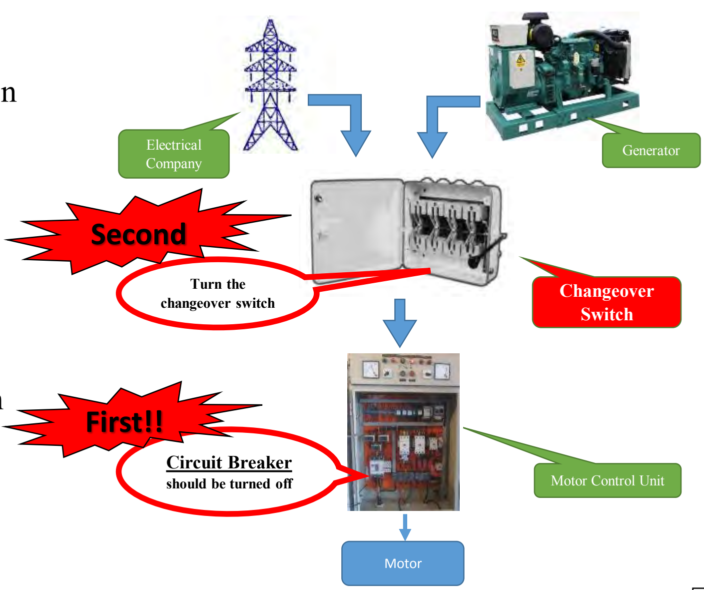
Circuit breakers

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

11/21

- 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 be sparked and get burnt if you operate it in the energized condition.



12/21

- 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.

Check List for Standard Operation Procedure

Evaluation Criteria

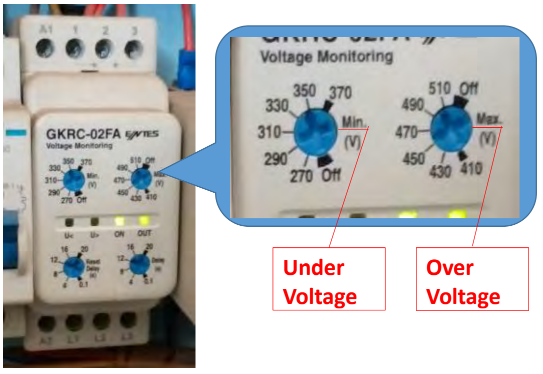
✓ : Good
× : No care at all or need to be newly installed
△ : Need to be improved
— : Not available to be checked

Inspection Items for Electrical Panel Condition													
Document			Visual (Outside)			Visual (Inside)			Operation		Settings		
Operation Record	Drawings	Vender Manual	Indications of Lamp/Switch	Status/Fualt Indication Lamps	Voltage /Ampere Meter	Cleanliness	Intrusion Path	Bypass-Circuit	How to operate changeover switch	Frequency of Start/Stop	Over/Under Voltage Relay	Over Current (Tharmal) Relay	Y-Δ Timer
Compare with the sample	Pump installation , electrical line ddiagram	Pump/Panel devices	all lamps/switches have name tag	all lamps are visibly bright enough	Proper functioning and zero adjustment	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	±10% of rated voltage of motor	Equall or less than rated current of motor	Not less than 2 seconds

Standard Settings of Protective Relays

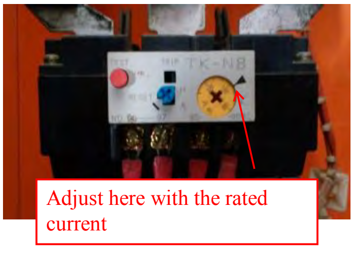
Over/ Under Voltage Relay:

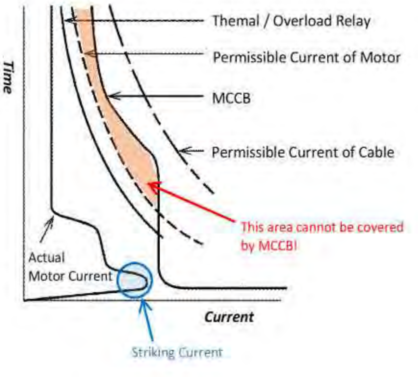
If the rated voltage is 400V, under voltage needs to be set 360V while over voltage is set at 440V, ideally



Standard Settings of Protective Relays

Thermal Overload Relay:





Standard Settings of Protective Relays

Timer Relay:

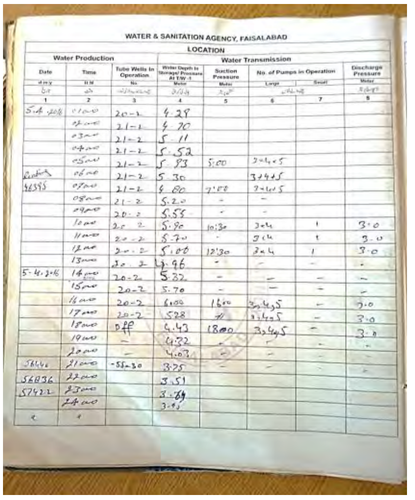
1 second seems too short

Setting 1 second like the left picture seems too short for a motor to increase its rotation enough. It is often seen at the site.
It is recommended to adjust at least 5 seconds.

If a circuit trips when you start a motor with a longer time duration of changeover as mentioned above, it is doubted that its current is relatively higher than the originally designed value and size of a circuit the breaker or thermal relay is too small to fit actual condition.

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
- 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 consumption
✓ Power factor
✓ Voltage
✓ Ampere

Identification of Hazards & Selection of Personal Protective Equipment (PPE) for Operations and Maintenance of Electrical Panels

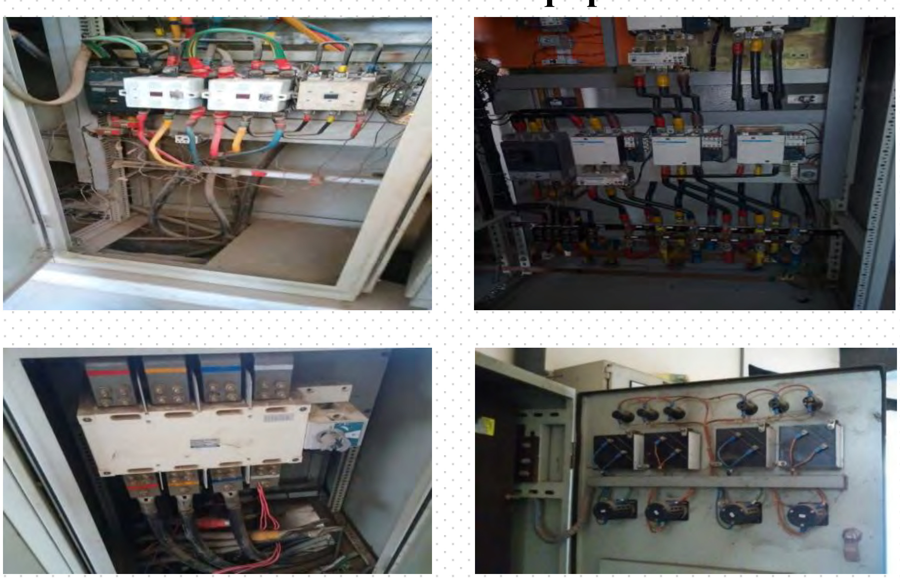
Team:

Mr. Hasebe Akira (JICA Expert)
Mr. Mubasher Ahmad Cheema (Course Leader)
Mr. Ihsan-ul-Haque Javed (Sr. Instructor Environment)
Mr. Jawad Shahid (Sr. Instructor Electrical)
Mr. Tanveer Shahzad (Young Professional)

Current Conditions of Electrical Panel & Instrumentation Equipment

3/13

Current Conditions of Electrical Panel & Instrumentation Equipment



4/13

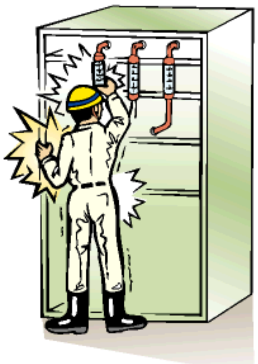
Hazards related to operations & maintenance of Electrical Panel

1. Loose electrical connections
2. Broken or damaged contact
3. No grounding
4. Broken base plate
5. Improper wiring connection

Hazards related to operations & maintenance of Electrical Panel

6. Exposed electrical parts
7. Trip and Fall
8. Wet & moist condition
9. Absence of safety label
10. Little or no housekeeping

Major outcomes of identified hazards



Electric shock

Electric fire

7/13

Hazard control during operations & maintenance

1	**Elimination :** Remove broken cable or Replace the old panel with new one
2	**Substitution:** Replacement of faulty or damaged electrical component.
3	**Isolation:** Keep electrical panel and operator protected from shot of water leak
4	**Engineering Control:** Install Earthing to prevent electric shock, repair broken panel door and keep locked
5	**Administrative Control:** Lock out / Tag out of faulty installation. Use of permit before O&M tasks and fixing warning signs
6	**PPE:** Use PPE, wear insulation gloves, Shoes with insulated sole and toe protection.

More Effective

Less Effective

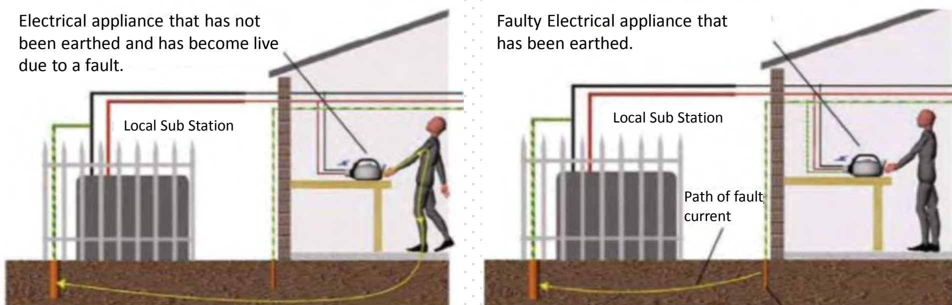
8/13

Safety measures for electrical panel room

Grounding

Electrical panel earth helps protect the operator.

Ground connection safeguards the operator and electrical panel if a malfunction causes the metal frame to become energized.



9/13

First Aid for Low Voltage Electric Shock

ARPITA KARKAREY'S
WALNUT
LEARNING SYSTEM

10/13

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 & local standards.
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)

- Insulated gloves
- Shoes with insulated sole and toe protection
- Helmet with attached Torch (when working in dark areas)
- Safety Vest

Ihsan Ul Haque Javed

Sr. Instructor (Environment)

PREVENTIVE MAINTENANCE

Goal of this Lecture

- Get familiar with the required equipment and tools
- Get the required skill to perform 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**

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.

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

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.

Inspection Tools

1. Voltage Tester

2. Screw Drivers Set

3.Pliers

6. Adjustable Wench

8.Ratchet Screwdriver

9. Ratchet Socket Wrench Set

Analysis and Testing Equipment

Preventive Maintenance Sheet for Electrical Facility

Site Name :

Approved by :

Supervised by :

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

Evaluation Criteria for Insulation Resistance

✓ : Good → more than 1.0MΩ
△ : Need to Adjust, Clean,Care → 1.0MΩ ~ 0.4MΩ
●: Need to repair immediately →less than 0.4MΩ
- : can not check

No.	Date	Wether	Approved by	Inspected by	Preventive Maintenance																Evaluation
					Visual Condition/Cleanliness						Bolt Tightening	Voltage by Clamp Meter (V)			Ampere by Clamp Meter (A)			Insulation Resistance (MΩ)			
					Clenliness	Neatness of Cabling	Cable Colour	Cable/wire Label	Proper Sealing	Terminal Cover		U	V	W	U	V	W	U	V	W	

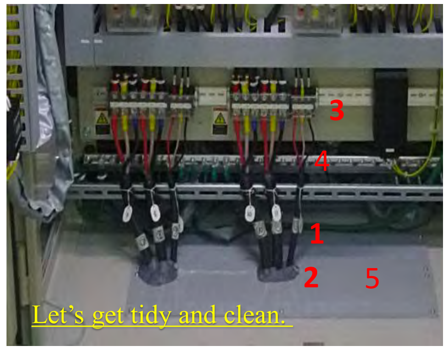
- Remarks -

Please make note here if anything ansual or you did some corrective actions.
Site conditions in detail shall be mentioned here with relevant Code Number.
(Bypass Connection, Noise, Overheat, Vibration, Foreign Object, Moisture, Dust, Sandy etc.)

Preventative maintenance

Bad Condition

Full of Dust! Even the conductive parts and terminals are covered by dust and some spider's nest can be also found.



Good Condition

1. Terminal Cover
2. Cable Colouring
3. Cable Label
4. Proper Sealing
5. No dust at the bottom

11/20

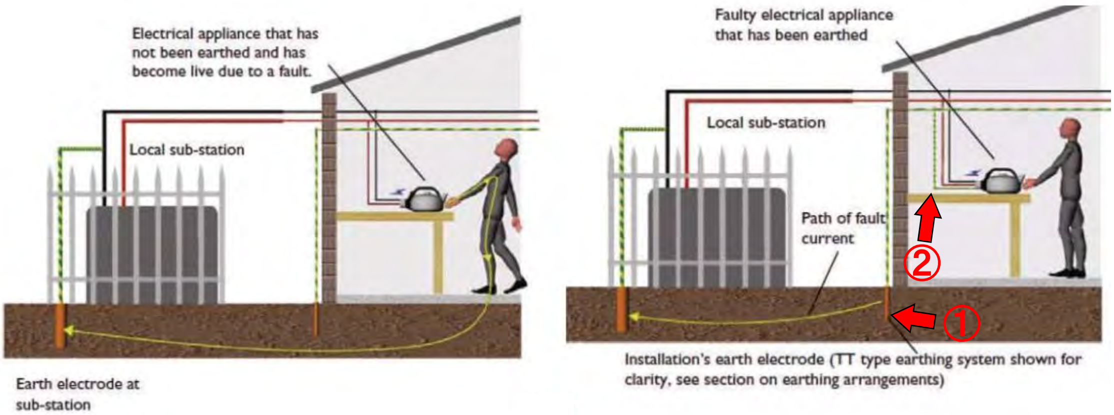
Electrical Leakage

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

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

12/20

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

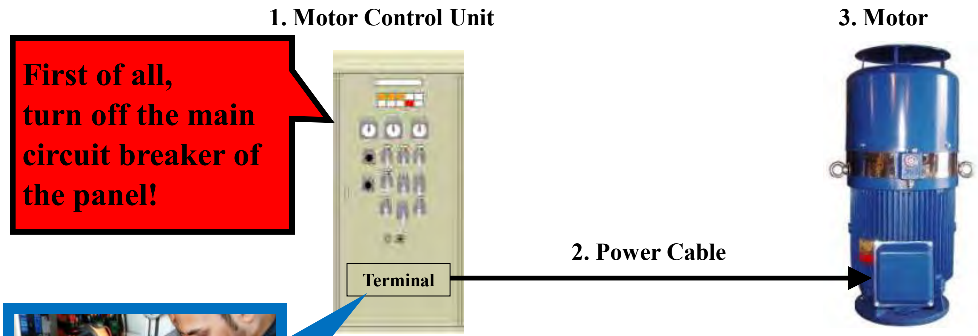
② Properly connect it with casing of electrical facility

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

Insulation Resistance Test

- Insulation resistance tester is a tool to check if the system has electrical leakage or not.
- First, checking leakage of the system largely at one time
- If leakage is found, check the system in detail in order to detect the faulty part

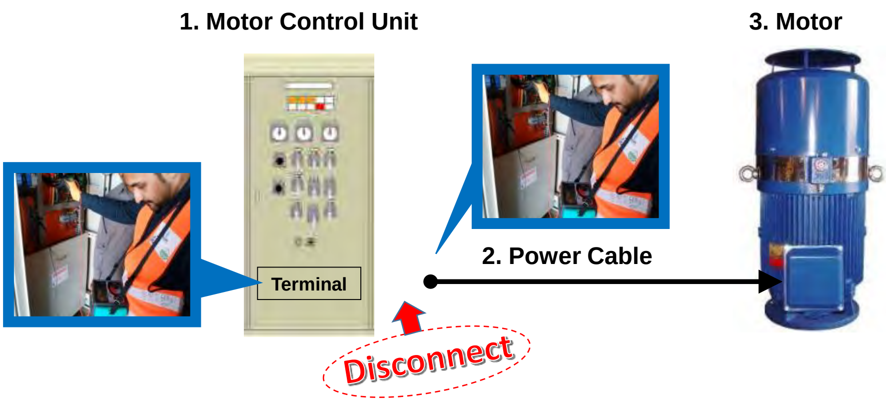
Insulation Resistance Test - Troubleshooting Procedure -



- ✓ Normally, insulation resistance should be greater than 1 MΩ
- ✓ Checking insulation resistance at the terminal of MCU to see whole system (1+2+3) at one time
- ✓ Please confirm breaker's OFF condition and no voltage remained at the terminal before you start the test

15/20

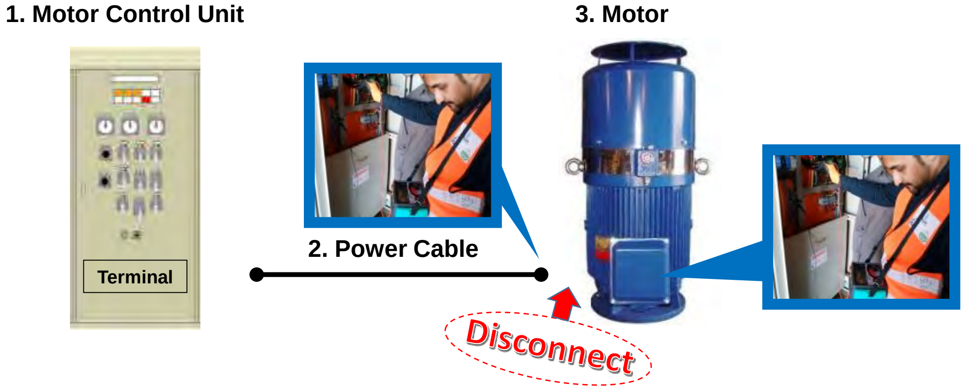
Insulation Resistance Test - Troubleshooting Procedure -



- ✓ If electrical leakage is found in the system, checking insulation resistance of MCU (1) separately from Power Cable and Motor (2+3) after disconnecting the cable from the terminal

16/20

Insulation Resistance Test - Troubleshooting Procedure -



- ✓ If electrical leakage is found in not MCU side but Power cable and Motor side, checking insulation resistance of Power Cable (2) separately from Motor (3) after disconnecting the cable from the terminal of motor
- ✓ If you found the parts with electrical leakage, consider repair or replacement.

17/20

Preventative maintenance

- Reduce uncomfortable operation 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

18/20

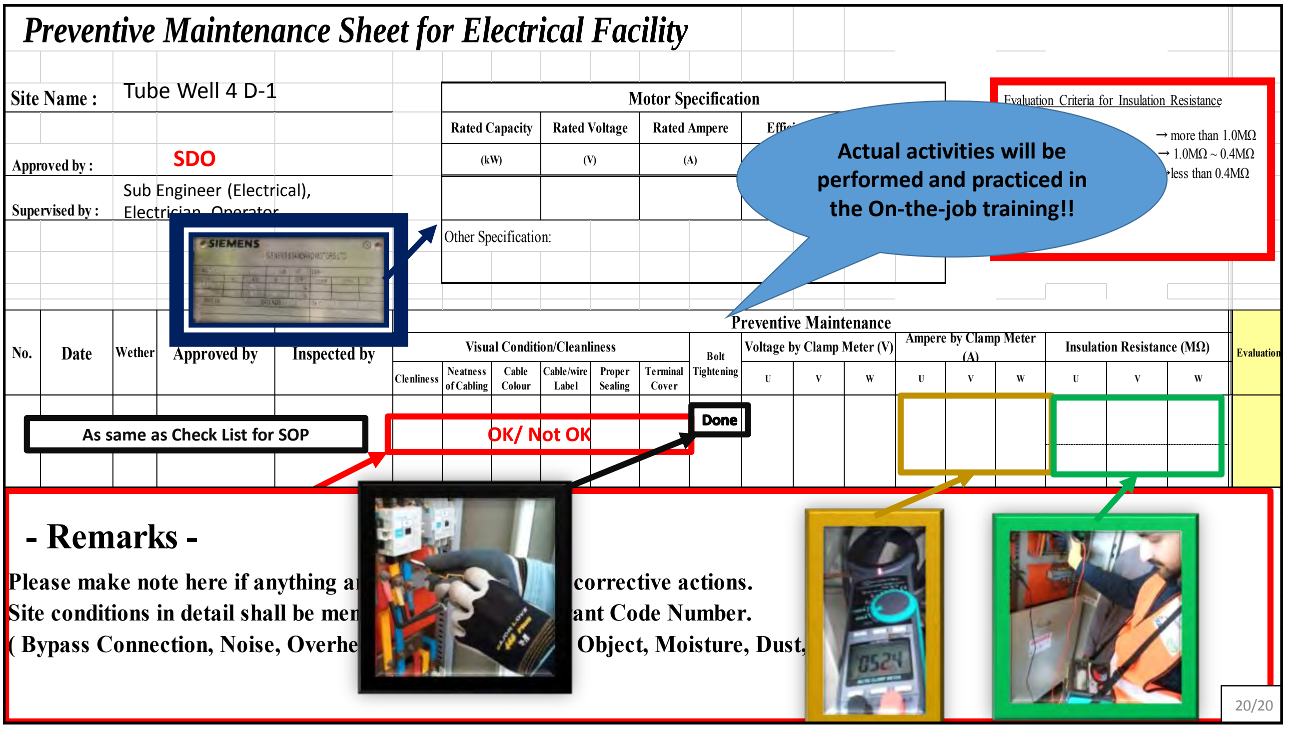
Suitable applications of preventative maintenance

Assets suitable for preventative maintenance include those that:

✓ Have a critical operational function

✓ Have failure modes that can be prevented (and not increased) with regular maintenance

✓ Have a likelihood of failure that increases with time or use



Action Plan

What is an action plan?

An action plan is a document that lists…

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

The purpose of an action plan…

✓ is to clarify what resources are required to reach the goal

✓ formulate a timeline for when specific tasks need to be completed

Action Plan Template

ALJAZARI ACADEMY

POST TRAINING ACTION PLAN

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

Name of Participant: Mubasher Ahmad Cheema

Name of Organization: Al-Jazari Academy

Action Plan Template

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

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

Action Plan Template

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

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

Action Plan Template

Please identify required resources to implement this plan.

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

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

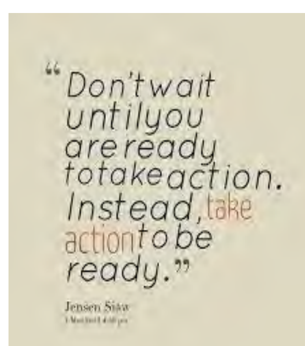
1. **Implementation approval**
2. **Management support**
3. **Required tools**

Action Plan Template

Other Comments or Notes:

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

What if not Action Plan?



OJT Implementation Procedure

~ Please let us work with you ~

OJT Implementation Procedure

1. Immediately perform what you have learnt **at one site in a few days**

2. **Share the result with instructor**, then correct it if necessary

3. Select several sites to perform and **please inform to the instructor**

4. Try to repeat the work at the sites on your own **along with OJT**

Dec 2016 – Feb 2017

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

Implementation Procedure

Let us know where you will perform and who are involved

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

Implementation Procedure

Sample

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

Implementation Procedure

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

Approved by	
Prepared by	

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

Implementation Procedure

Sample

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

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

Implementation Procedure

We are very much Expecting…

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

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

It would be greater if you write down

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

WASA : Lahore   Division : Nishter Town

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

Ideal Goal

WASA : Lahore

Division : Nishtar Town

Approved by: Shakeel Kashmiri – Director

Prepared by: Shammas Ayoub – SDO Green Town

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

OJT Implementation Procedure

1. Immediately perform what you have learnt **at one site in a few days**

2. **Share the result with instructor**, then correct it if necessary

3. Select several sites to perform and **please inform to the instructor**

4. Try to repeat the work at the sites on your own **along with OJT**

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

Wrap-up

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

We will look forward to your response.

O & M of Mechanical and Electrical Equipment
WSD 5231

Generators

Module 3

ALJAZARI
ACADEMY

Agenda

- ✓ Ice Breaker and Class Introduction
- ✓ Resources and handouts
- ✓ Introduction to generators
- ✓ Basic design of generators

Agenda

- ✓ Electrical components of generator
- ✓ Periodic Maintenance and record keeping
- ✓ Reliability based preventative maintenance.
- ✓ Troubleshooting for various failures

Icebreaker and 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?

Icebreaker and Class Introduction

Now it is your turn…

- ✓ Degree and backgrounds?
- ✓ Share your work experience relative to Generators?

Resources and Handouts

- ✓ Generator Assembly Exploded View Chart
- ✓ Generator Operational Flow Diagram
- ✓ Equipment owner's manual
- ✓ OEM Trouble shooting charts
- ✓ Lecture notes
- ✓ JICA textbook

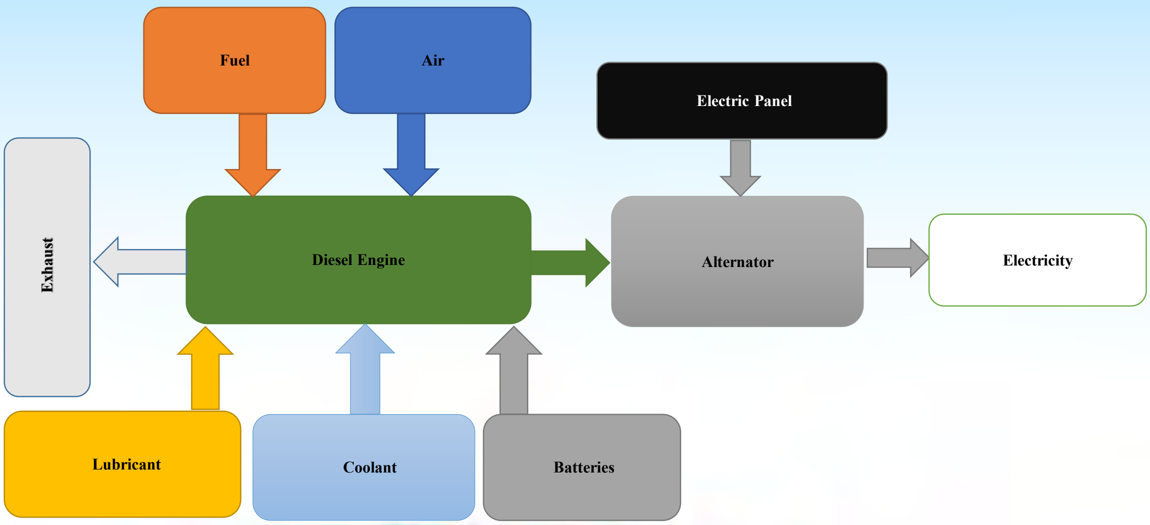
Introduction to Generators

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

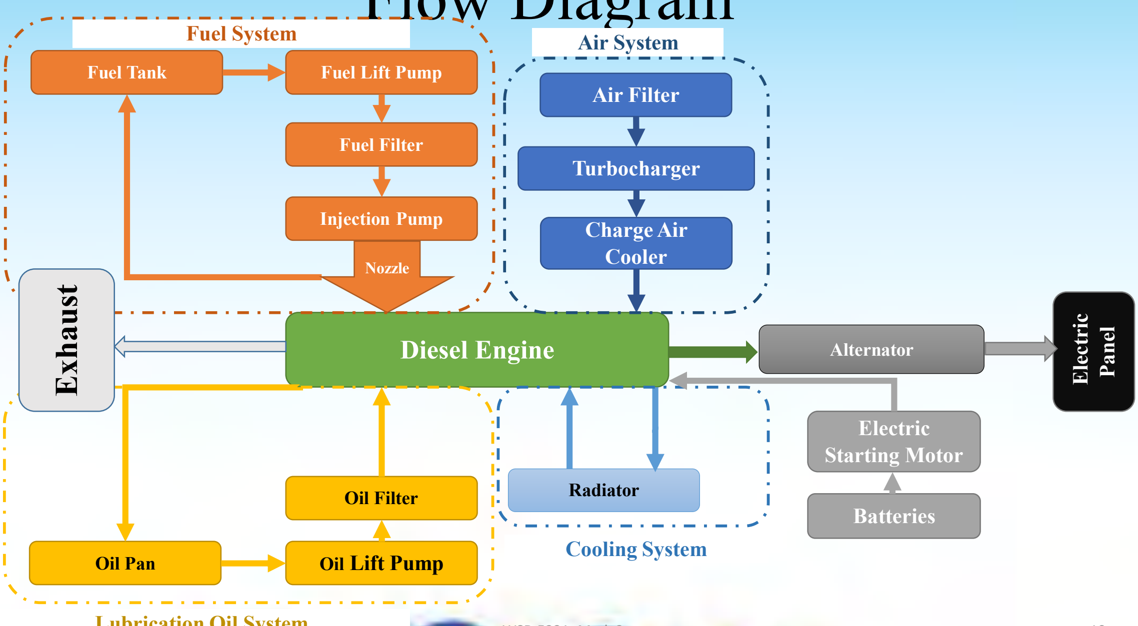
- ✓ Principle of Generator
- ✓ Frequency of the synchronous generator is determined according to the rate of rotation
- ✓ Basic components of Generator:

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

Block Diagram of generator



Flow Diagram



Flow of Systems

1. Starter motor starts operation using power supplied by batteries

2. Crank of engine starts rotating

3. Cylinder of engine leads ignition using fuel and air and shift to combustion cycle

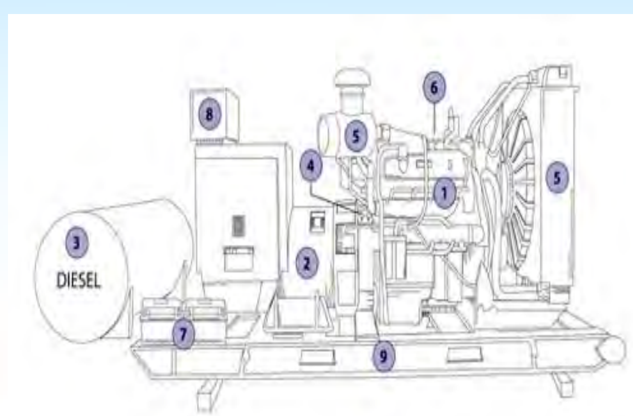
4. Rotor of alternator gradually accelerate to rotate through engine shaft

5. Stator of alternator generate power

Basic design of generator

- ✓ Components of a diesel generator
- ✓ Main components of a diesel generator

1. Engine
2. Alternator
3. Fuel System
4. Voltage Regulator
5. Cooling and Exhaust Systems
6. Lubrication System
7. Battery
8. Control Panel
9. Main Assembly / Frame



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

Engine Check

- ✓ Monitor fluid levels, oil pressure, and coolant temperatures frequently.
- ✓ Look and listen for changes in engine performance, sound, or appearance that will indicate that service or repair is needed.
- ✓ Be alert for misfires, vibration, excessive exhaust smoke, decreases in power, or increases in oil or fuel consumption.

Engine

2.Alternator

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

Alternator

- ✓ Alternator consists of an assembly of stationary and moving parts encased in a house. Movement of it's components generates electricity.

- ✓ Stator: A Stationary component.
- ✓ Rotor / Armature: A Moving component. It produces a rotating magnetic field in any one of the following three ways.

- By induction.
- By permanent magnets
- By using an exciter

3.Fuel System

- ✓ The fuel tank usually has sufficient capacity to keep the generator operational for 6 to 8 hours on an average.
- ✓ In the case of small generator units, the fuel tank is a part of the generator's skid base or is mounted on top of the generator frame.

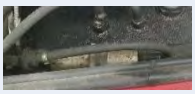
Fuel System

Fuel System Check

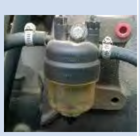
- ✓ With the generator set operating, inspect the fuel supply lines, return lines, filters, and fittings for cracks or abrasions.
- ✓ Make sure the lines are not rubbing against anything that could cause an eventual failure.
- ✓ Repair any leaks or alter line routing to eliminate wear immediately.

Fuel System

Components of Fuel System

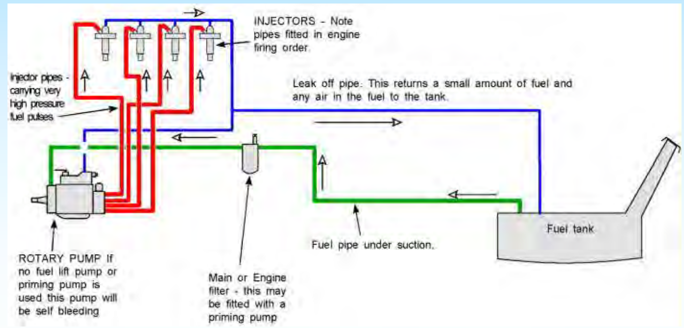
Sr. No.	Name of Component	Purpose	Operation	Maintenance
1	Fuel Tank 	Its purpose is to store enough fuel for combustion.	It provide fuel for the combustion	Its cover should be tight and clean. No water and dirt at the top of the tank. Always confirm enough amount of fuel remained for emergency.
2	Fuel Lift Pump 	Use to lift the fuel from the fuel tank	It gets electrical power and send the fuel towards the fuel filter	It should be clean. Its electrical connections must be checked on regular basis
3	Fuel Filter 	To remove any solid particle in fuel	Its specific size and design allows the fuel to pass through the filter and stops the solid dust or other particles from entrance to the system	Fuel filter must be checked and replaced at regular maintenance basis (Depends upon User Manual)

Components of Fuel System

Sr. No.	Name of Component	Purpose	Operation	Maintenance
4	Fuel Water Separator 	To separate and remove water from the fuel	Fuel floats on the water due its lower density than the water. Water is then removed by opening the valve at the bottom of the filter	It must be checked daily and water should be drain before operating the generator, if water is found in it
5	Injection Pump 	To inject fuel through nozzles at certain pressure	It is connected to the injection nozzles and provide fuel at specific pressure	It should be clean. Its electrical connections must be checked on regular basis
6	Nozzle	To throw fuel into the cylinders in small particle form	Fuel enters into the cylinder from these nozzles	Check the leakage of the fuel around it. Yearly based maintenance may be required (Depends upon manufacturer's user manual)

Fuel System- Areas of concern

- ✓ Fuel System
- ✓ Check for leaks.
- ✓ Floor of enclosure
- ✓ Side, front, rear of engine
- ✓ Piping seeping
- ✓ Fuel tank level 1/2 or more
- ✓ Cracked or hardened fuel lines.



4.Automatic Voltage Regulator

This component regulates the output voltage of the generator, it increases and decreases the rpm's diesel engine according to load to maintain the frequency.

AVR

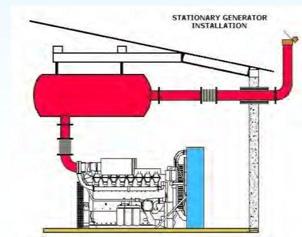
5.Cooling & Exhaust Systems

Cooling System

- ✓ Continuous usage of the generator causes its various components to get heated up.
- ✓ It is essential to have a cooling and ventilation system to withdraw heat produced in the process.

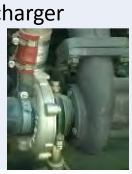
Exhaust system

- ✓ Exhaust fumes emitted by a generator contain toxic chemicals that need to be properly managed.



Cooling and Exhaust system

Components of Air System

Sr. No.	Name of Component	Purpose	Operation	Maintenance
1	Air Filter 	To clean air from dust particles	Its filter size is so adjusted that air can as through it but any dust particle cannot pass through the filter	Cleaning of the dust at regular interval Replacement of filter after manufacturer's recommended interval
2	Turbocharger 	To compress air before intake	It takes power from the exhaust gases which tends to rotate it to compress the air	Check the leakage points from the joints

Components of Air System

Sr. No.	Name of Component	Purpose	Operation	Maintenance
3	Charge Air Cooler	Its purpose is to reduce the intake manifold temperature and to meet the lower emission requirements		Clean it on regular basis as per O&M manual of the manufacturer
4	Intake Valve	Its purpose is to provide enough fresh air for the combustion in every necessary moment		No regular maintenance required. For periodic maintenance please refer to the O&M manual of the manufacturer

5b. Cooling System

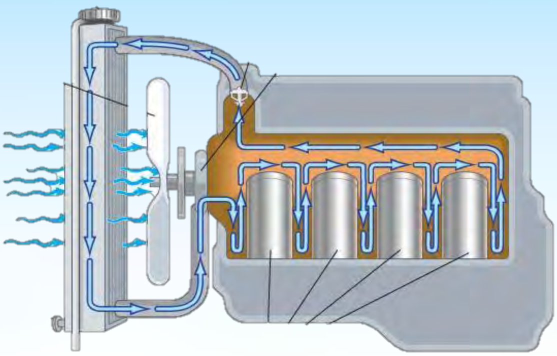
Function:

This system maintains the temperature of the engine assembly by keep introducing the cool water into them. After working in the cylinder the temperature of water increases which is reduced by using radiator and fans

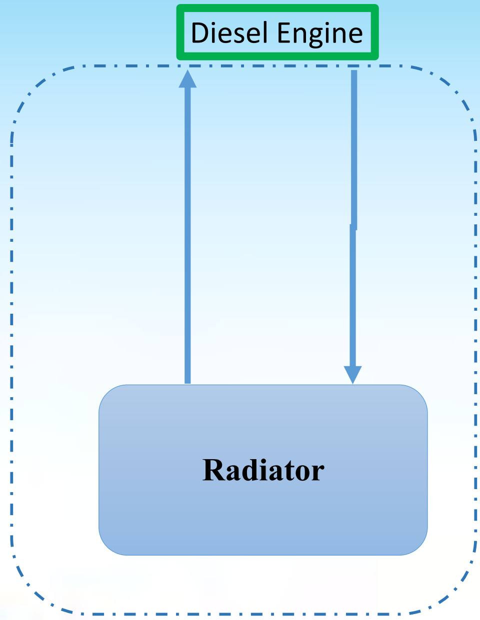
Components:

1. Radiator/ Charge air cooler
2. Thermostat

5b. Cooling System



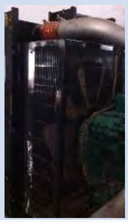
Cooling system



Components of Cooling System

Sr. No.	Name of Component	Purpose	Operation	Maintenance
1	Coolant	To avoid the overheating of the engine	It passes through the heated parts of the engine and maintain the temperature	Check the concentration of the antifreeze and level of the coolant at regular interval.
2	Radiator 	To reduce the temperature of the coolant	Coolant passes through the series of pipes. Fresh air from fan reduce the temperature of the coolant, passes through the series of pipes.	Check the leakages in the cooling system

Components of Cooling System

Sr. No.	Name of Component	Purpose	Operation	Maintenance
3	Fan 	Provide fresh air for radiator and engine	It gets electrical energy from the generator and throw air towards radiator	Proper cleaning is required. Check and tight the electrical connections at the terminals
4	Thermostat	It controls the flow of water depending upon its temperature		

Cooling System

- ✓ 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

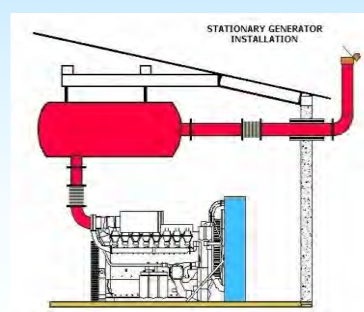
Cooling System

✓ 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 & Exhaust Systems

Exhaust system

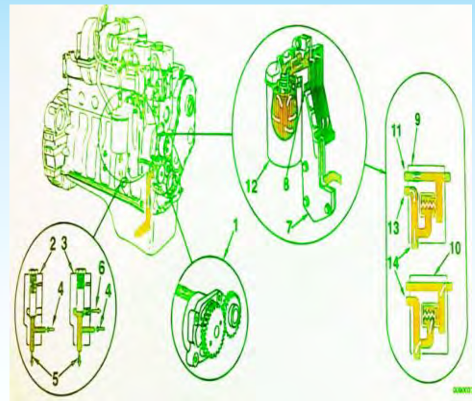
• *Exhaust system*: With the generator set operating, inspect the entire exhaust system, including the exhaust manifold, muffler, and exhaust pipe. Check for leaks at all connections, welds, gaskets, and joints — and make sure that the exhaust pipes are not heating surrounding areas excessively. Repair any leaks immediately. Check for excessive smoke upon starting: It can indicate possible performance and air quality issues that may require immediate attention.



Cooling and Exhaust system

6.Lubricating System

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



Lubrication system for diesel generator

7.Battery Charger

- ✓ The start function of a generator is battery-operated.
- ✓ The battery charger provides the Float Voltage to the Generator whose Variation induces changes in the Generator's operation.
- ✓ Battery chargers are usually made of stainless steel to prevent corrosion

Battery Charger

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.

8.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
- ✓ Other controls

Electrical Control panel

Control Panel

Control system: Inspect the control system regularly, and make sure it is logging data properly during engine exercise. Be sure to return the control system back to normal automatic standby (AUTO) when testing and maintenance are completed.

Electrical Control panel

Control Panel-Areas of concern

- Engine Controller
- Check alarm status- Low fuel, oil, voltage
- Check engine instrumentation
- Check A/C generator instrumentation
- No amp load if generator is not transferred

9.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

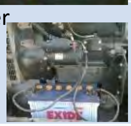
Fluid analysis program

- Types
- Oil
- Coolant
- Fuel
- Benefits
- Determine engine and generator problems before expensive failures.

Electrical components of generator

1. Automatic voltage regulator
2. Engine gauges
3. Generator gauges
4. Control panel
5. Alternator
6. Battery charger

Components of Electrical System

Sr. No.	Name of Component	Purpose	Operation	Maintenance
1	Alternator 	It is the main component of the generator which is responsible for the production of Alternating current	It rotates at specific speed and produce the electrical energy	Should be clean and there should be no sparking at the connection terminals
2	Battery 	To provide starting current to the starter	It provide DC current to start the operation of generator.	Regular checking of water level and proper connections at the terminals
3	Starter 	It purpose is to start the generator from the rest position		Should be clean and connections at the terminals must be checked regularly

Components of Electrical Panel/ System

Sr. No.	Name of Component	Purpose	Operation	Maintenance
4	Electric Panel 	To monitor the system through electronic sensors and provide smooth electrical energy	It operates with the devices such as MC, CB, Relays, sensors etc. to monitor and ensure the rated electricity in a safe way	Proper cleaning and routine checkups are necessary for the smooth operation Especially confirm no alarm indication on the display
5	Cables 	To provide electrical connectivity among alternator panel and other electrical components	They transfer electrical energy produced at the alternator to the electric panel for use.	Proper connectivity at the terminals by tightening the bolts etc.

1.Automatic Voltage Regulator

AVR can stabilize the voltage value when there is a sudden change of load. If the generator is running in parallel condition, the AVR can control the voltage that it produce to ensure equal value for reactive load sharing.

AVR for brushless Generators

2.Engine gauges

- ✓ These engine gauges display the running parameters of the generators.
- ✓ Constant measurement and monitoring of these parameters enables built-in shut down of the generator when any of these cross their respective threshold levels.

Engine gauge

3.Generator gauges

Alternator gauges are connected to electronic control panel and are capable of measuring voltage, current, operating frequency, power factor, etc.

Generator gauge

4.Control Panel

The control panel displays all the information transmitted through sensors and gauges of both engine and alternator.

Control panel

6.Battery Charger

- ✓ The start function of a generator is battery-operated. The battery charger provides the Float Voltage to the Generator whose Variation induces changes in the Generator’s operation.
- ✓ The battery charger has an isolated DC voltage output that does interfere with the normal functioning of the generator.

Battery charger

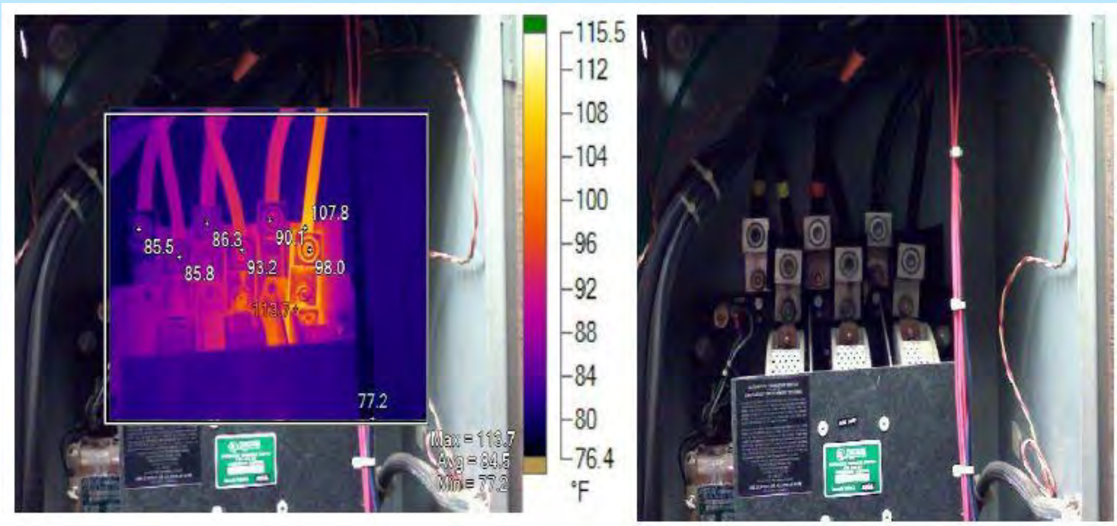
Thermographic Predicative Maintenance

- Before an electrical component burns up, it heats up.
- Infrared Thermographs finds the problems early in the failure cycle. Early detection allows maintenance personnel to take corrective action before a component fails, minimizing damage to the component, reducing repair costs, eliminating production losses, preventing safety hazards and saving energy.

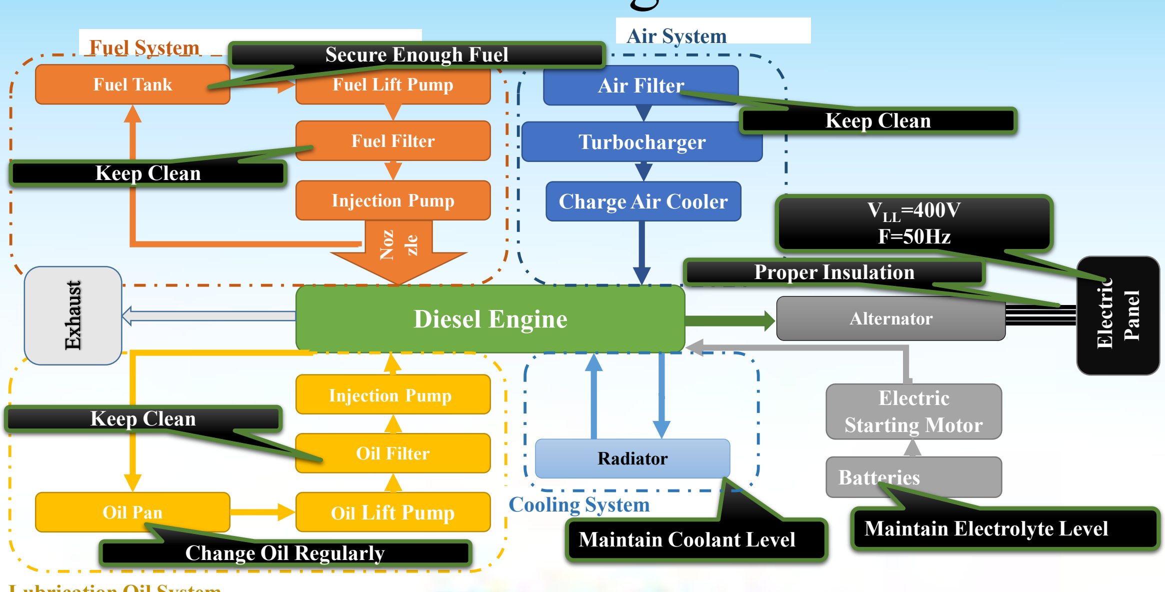
The benefits of Thermal Imaging

- Determines if the components and system have been properly installed and are not damaged
- Reduces downtime
- Reduces risk of equipment failure
- Increases safety
- Improves insurability
- Improves system performance
- Determines whether components and systems operate properly and meet the design intent
- Saves money

The benefits of Thermal Imaging



How should the generator be?



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

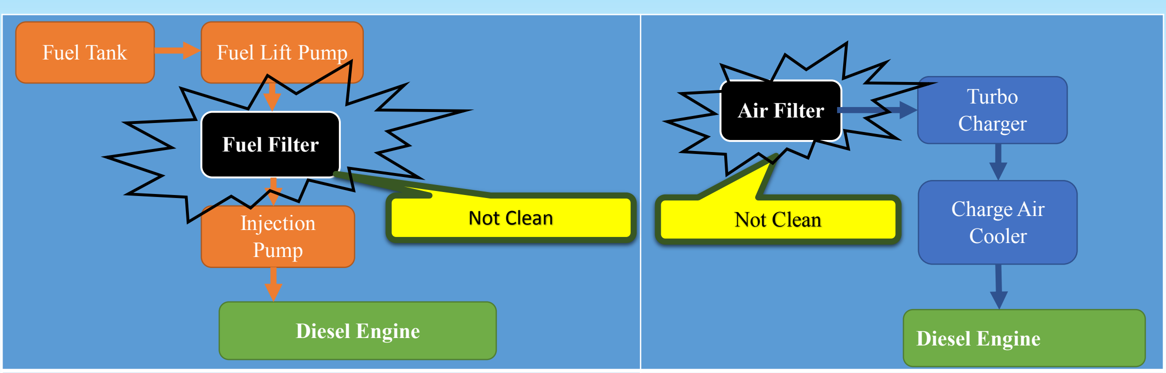
d. Sudden changes in engine operating temperatures

e. Excessive smoke

f. Increase in oil consumption

g. Increase in fuel consumption

Necessity of maintenance



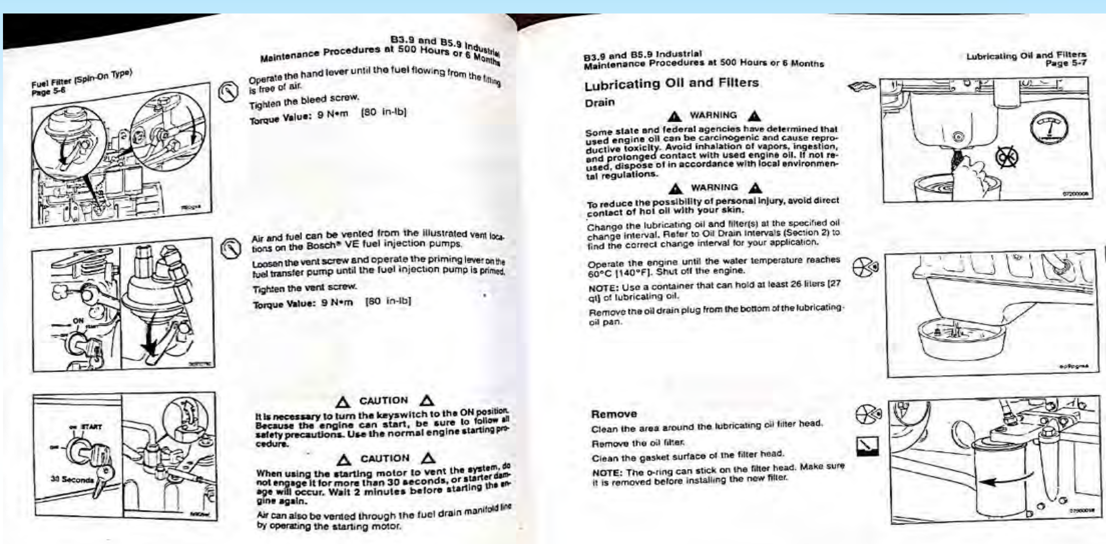
Problems: • **Engine Misfires** • **Engine Runs Rough** • **Low Output Power**	**Problems:** • **Engine Misfires** • **Dark Smoke** • **Lower Acceleration**
Remedy: • **Replace or clean the fuel filter**	**Remedy:** • **Replace or clean the air filter**

Introduction of manufacturer's O&M manual

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

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

Introduction of manufacturer's O&M manual



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

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

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

Tighten the bleed screw.

Torque Value: 9 N•m [80 in-lb]

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

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

Tighten the vent screw.

Torque Value: 9 N•m [80 in-lb]

△ CAUTION △

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

△ CAUTION △

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

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

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

Lubricating Oil and Filters
Page 5-7

Lubricating Oil and Filters

Drain

▲ WARNING ▲

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

▲ WARNING ▲

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

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

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

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

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

Remove

Clean the area around the lubricating oil filter head.

Remove the oil filter.

Clean the gasket surface of the filter head.

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

Basic 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

Basic 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

Basic 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

Capacity Calculations

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

Capacity Calculations

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

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

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

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

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

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

Capacity Calculations

Example: Ameer Chowk Disposal Station, Green Town, Lahore

Pump Serial No.	Average Running Duration (Hours)	Pump Rating	Motor Rating (HP)	Design Head (Feet)
1	12	7.5-Cfs	60	35
2	12	7.5-Cfs	60	35
3	4	7.5-Cfs	60	35
4	4	7.5-Cfs	60	35

Roughly assume that it is 20% of the total non-motor load

Reliability based preventive maintenance

- ✓ Periodic maintenance schedule
- ✓ Typical industrial generator Service and Maintenance plan

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

Start and observe

Standard operating procedure for 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

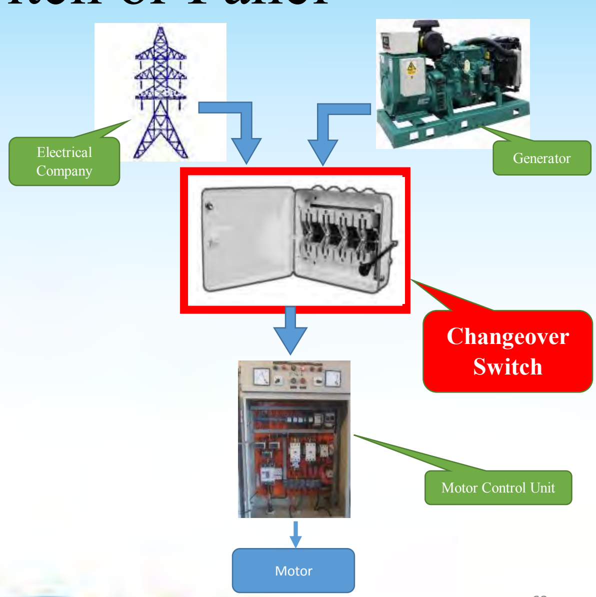
- **Wait for 30-40 seconds till confirming voltage and frequency get stable enough**
- **Turn on the circuit breaker of the motor control unit**

Observe the operation

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

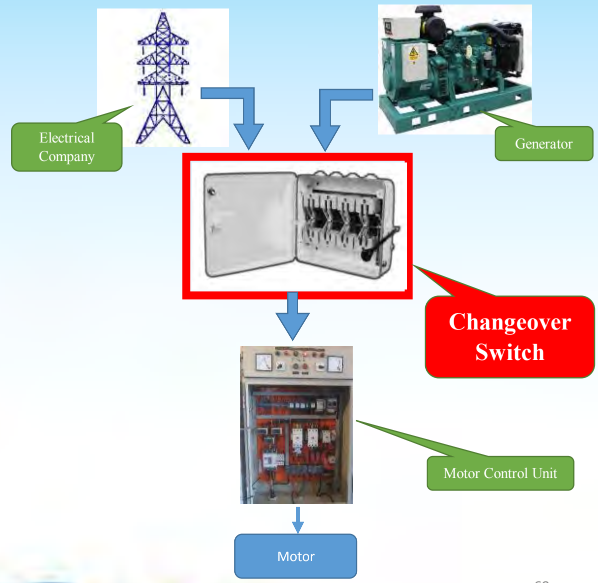
Changeover switch or Panel

✓ 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



Changeover switch or Panel

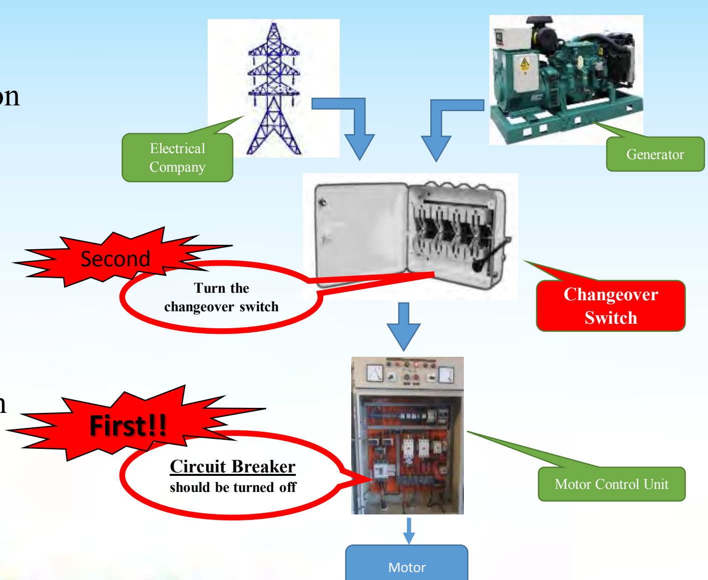
- ✓ Change over Panels are used to switch between primary and auxiliary power source. It is used in case of multiple connections from the electric supply company or generators



69

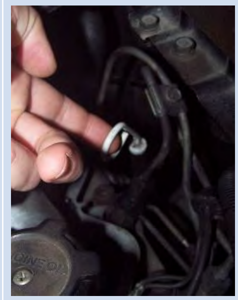
- How to operate changeover switch -

- ✓ 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 be sparked and get burnt if you operate it in the energized condition.



70

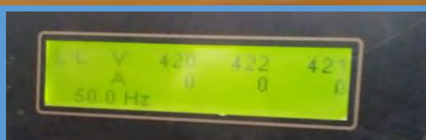
Parameters To Be Cared For Before Operation

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

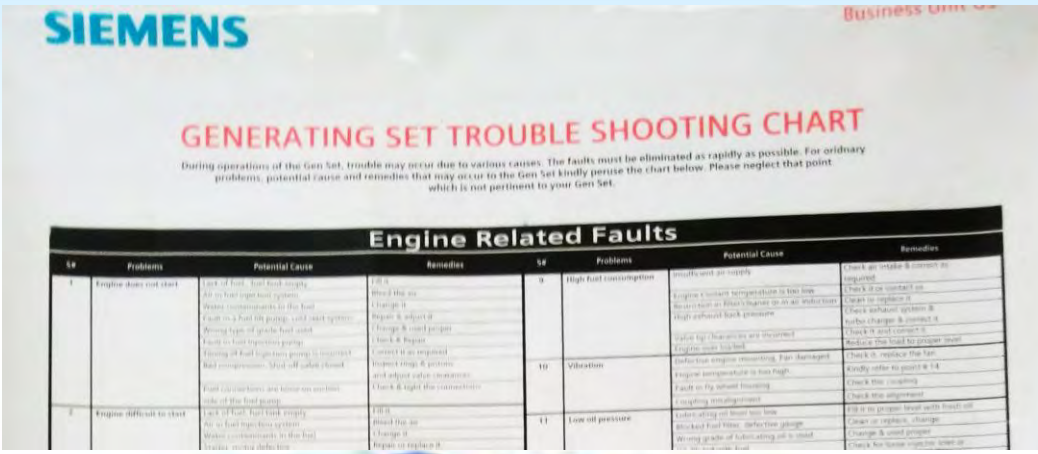
1. Voltage	2. Frequency	3. Current	4. Over Heat
 			

Parameters To Be Cared For During Operation

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

Possible Fault Situation

Many faults can be occurred due to over use of generators, because of shortage of electricity.
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
		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

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					

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

Daily and Periodic Maintenance Sheet

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

Daily Maintenance Checks

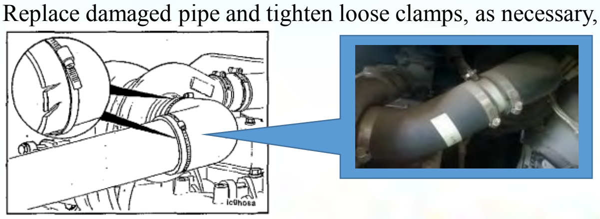
<u>Cleaning</u>
No dust particles, insects etc. should be present in the generator. Cleaning of the machine must be given the top priority.

<u>Lamp test</u>
To ensure the timely and accurate indication of the warning or fault, lamp test must be carried out on daily basis. In case of a faulty lamp, please check the connections and joints. The lamp must be replaced immediately, if found faulty.

Daily Maintenance Checks

<u>Electric panel</u>
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.

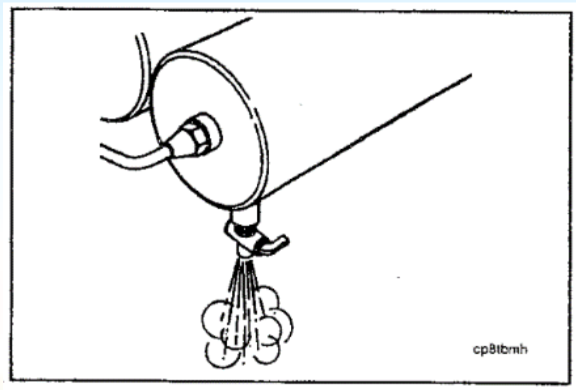
<u>Air intake piping</u>
Visual inspect:
•Intake piping wear points
•Damages to piping
•loose clamps or punctures that can damage the engine
Replace damaged pipe and tighten loose clamps, as necessary, to prevent the air system from leaking.



Daily Maintenance Checks

Air tank and Reservoir

If automatic purging or spitter valves are used, confirm the valves are opening correctly. If a manual drain valve is used on the wet tank, open the drain cock on the wet tank to drain any moisture accumulated in the air system.

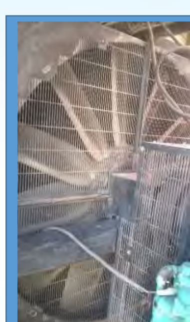


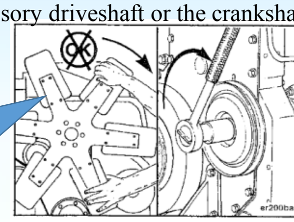
Daily Maintenance Checks

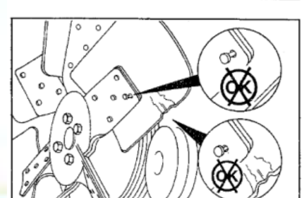
Cooling fan

A visual inspection of the cooling fan is required daily. Check for cracks, loose rivets, bent or loose blades. Check the fan to make sure it is securely mounted.

It is important to note that one should not rotate the engine by pulling or prying on the fan. The fan blades can be damaged and cause personal injury or property damage. Use the accessory driveshaft or the crankshaft barring tool to rotate the crank shaft.







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:

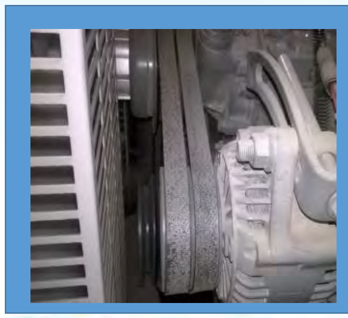
Incorrect tension, size or length

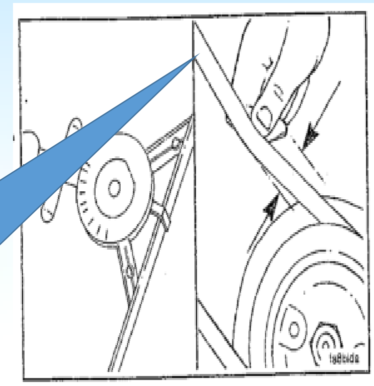
•Pulley misalignment

•Severe operating environment

•Oil or grease on the side of the belt

•Aging degradation





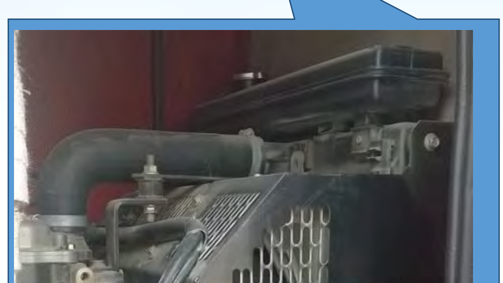
Daily Maintenance Checks

Engine coolant level

•Do not remove the pressure cap from the hot generator. Wait until the coolant temperature is below 50^{o}C before removing the pressure cap.

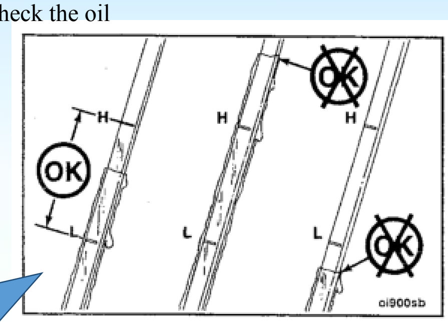
•Never use the sealing addictive to stop the leakages in the cooling system. This can result the cooling system plugging and inadequate coolant flow, cause engine to overheat.

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

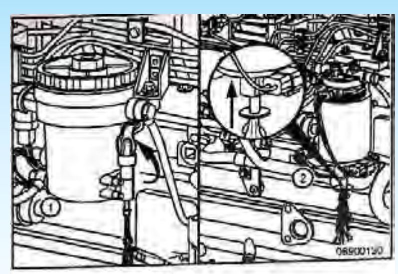


Daily Maintenance Checks

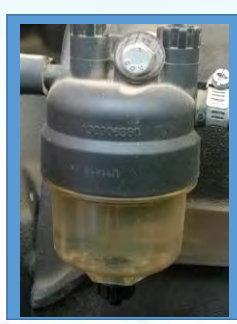
<u>Engine lubrication oil level</u>
The engine must be level to check the lubrication oil level. Shut off the engine for an accurate reading. Wait at least 15 minutes after shutting off the engine to check the oil level. This allows oil the time to drain into the oil pan.

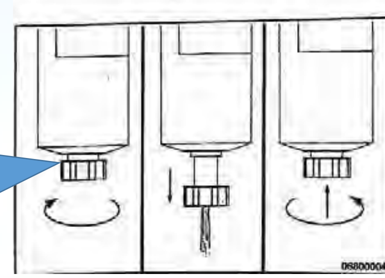


Daily Maintenance Checks



<u>Fuel water separator/ filter</u>
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.

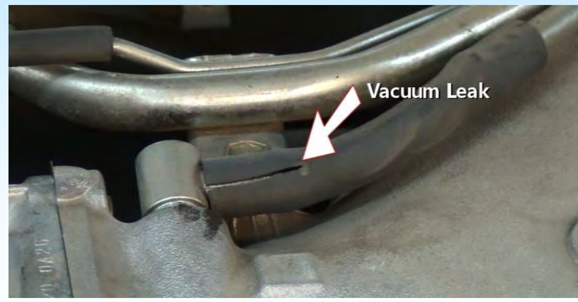




General information

To look for,

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



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

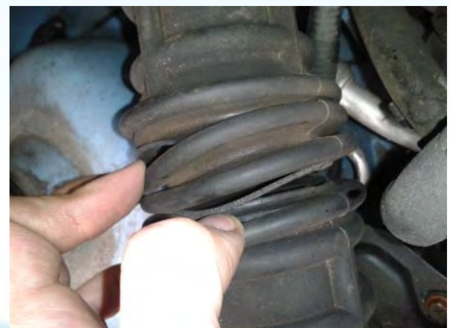
Air Intake Piping

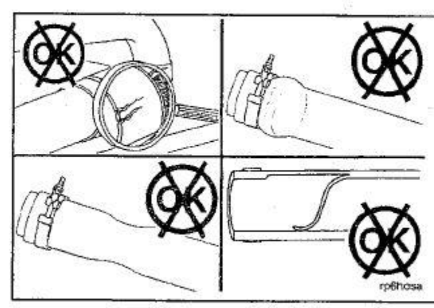
- Maintenance check

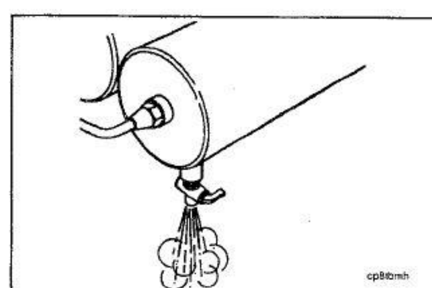
Visually inspect piping points for wear points and damage, loose clamps or punctures.

Replace damage piping and replace loose clamps.

Max torque value 8 N.m







Fan, Cooling

- Inspect for Reuse

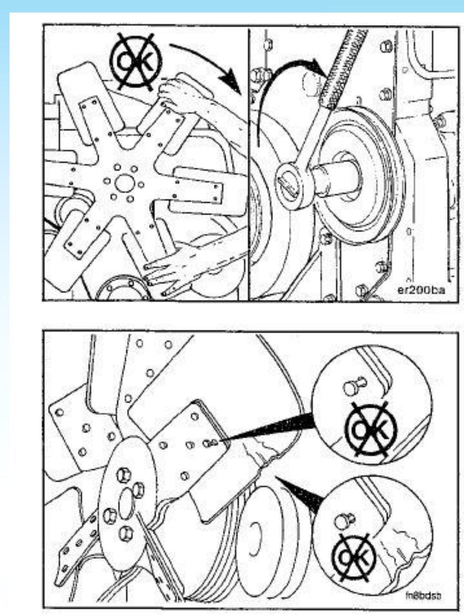
Visually inspection is required to check for cracks, loose rivets and bent or loose blades.

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.

Fan, Cooling

Do not straighten a bent fan blade or continue to use a damaged fan, It may fail and cause personal injury.

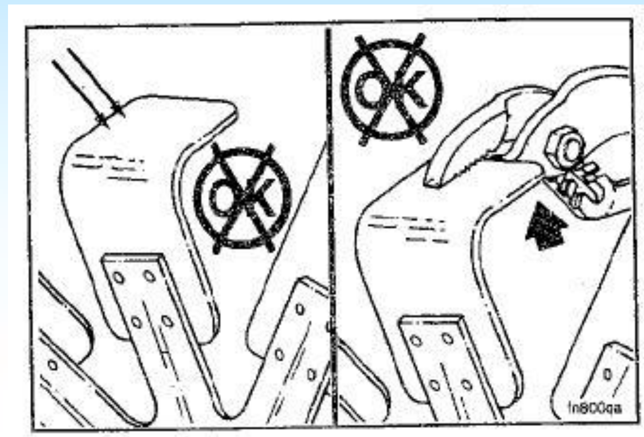
Replace original equipment fan that is damaged with a fan of the identical part number.



Fan, Cooling

Do not straighten a bent fan blade or continue to use a damaged fan, It may fail and cause personal injury.

Replace original equipment fan that is damaged with a fan of the identical part number.



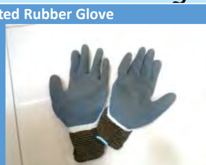
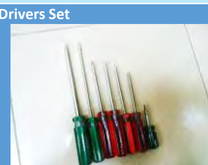
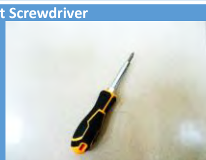
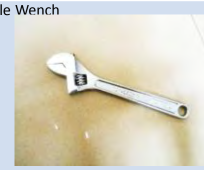
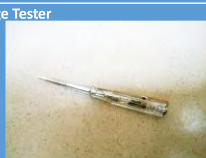
Crankcase Breather Tube

- Inspect the breather tube for sludge, debris etc.

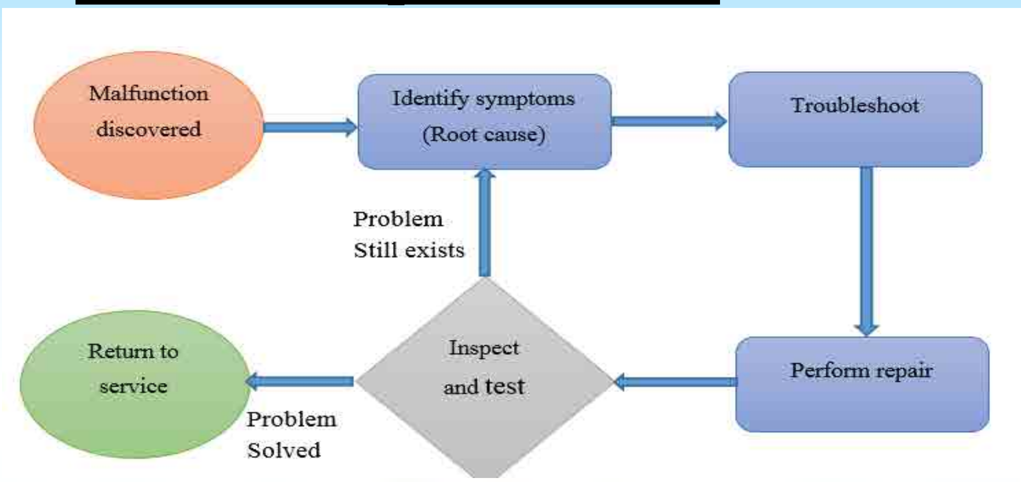
Crankcase Breather Tube

- Inspect the breather tube for sludge, debris etc.

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 	

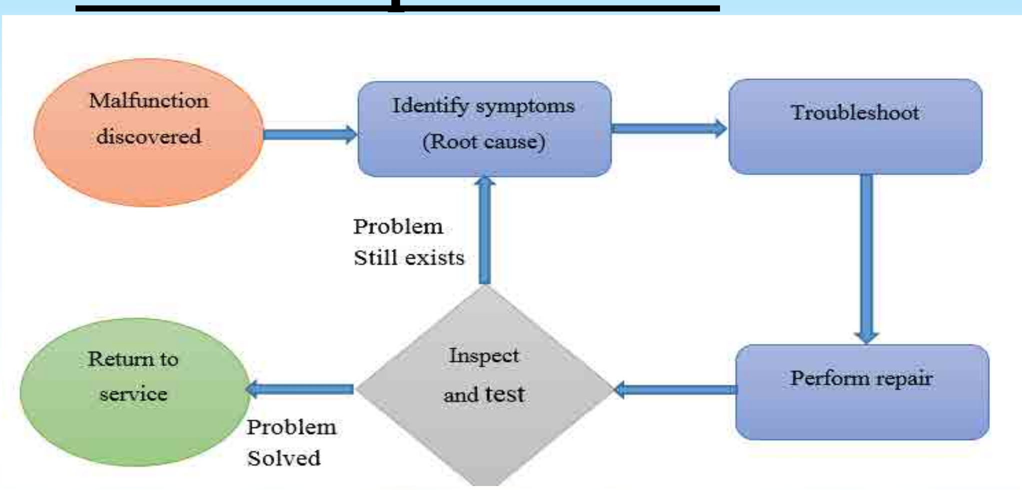
General Repair Process



OJT Implementation Procedure

ITEM	2 Yrs	3000 Hrs	4000 Hrs	6000 Hrs or 3 Yrs	12000 Hrs or 6 Yrs
Change cooling system coolant					
Test/change fuel injector					
Change cooling system coolant					
Clean/test aftercooler core					
Add cooling system coolant extender (ELC)					
Change cooling system coolant (ELC)					

General Repair Process



Preventative maintenance and record keeping

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	

Record keeping

Annual maintenance and inventory chart

Annual maintenance plan

Sr. No.	Activities	Parts Type	Required Quantity	Unit Price	Sub Total Cost	Supplier	Service Type	Operating Hours	Service Type				Last Activity Date	JAN	FEB
									Weekly	Monthly	6 Months	Yearly			
1	Check and Clean Air Cleaner								•						
2	Check Battery Charger								•						
3	Drain Fuel Filter								•						
4	Drain Water From Fuel Tank								•						
5	Check Coolant Concentration									•					
6	Check Drive Belt Tension									•					
7	Drain Exhaust Condensate									•					
8	Check Starting Batteries									•					
9	Change Oil and Filter										•				
10	Change Coolant Filter										•				
11	Clean Crankcase Breather										•				
12	Change Air Cleaner Element										•				
13	Check Radiator Hoses										•				
14	Change Fuel Filters										•				
15	Clean Cooling System										•				
16	Cooling fan belt tensioner											•			
17	Fan hub, belt driven											•			
18	Overhead set											•			
19															
20															
				Total											

Daily operational record keeping chart

Daily and Periodic Maintenance Sheet

Sr. No.	Activities	Service Type				Last Activity Date	Month ______ Year ______																														
		Daily	Weekly	Monthly	6 Months		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
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				•																																

Wrap-up

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

Working of Diesel Generator

Operational Maintenance of Diesel Generator

Daily Maintenance Procedures

General information

To look for,

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

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

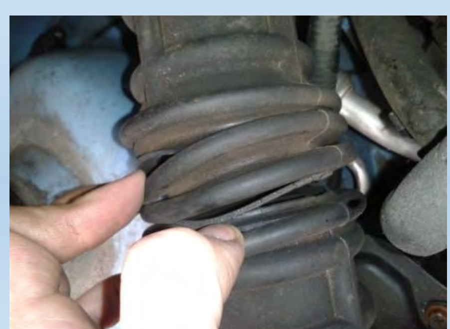
Air Intake Piping

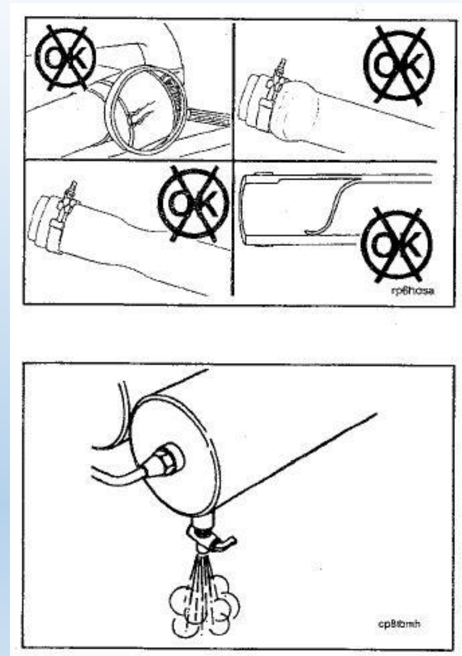
- Maintenance check

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

Replace damage piping and replace loose clamps.

Max torque value 8 N.m





Fan, Cooling

- Inspect for Reuse

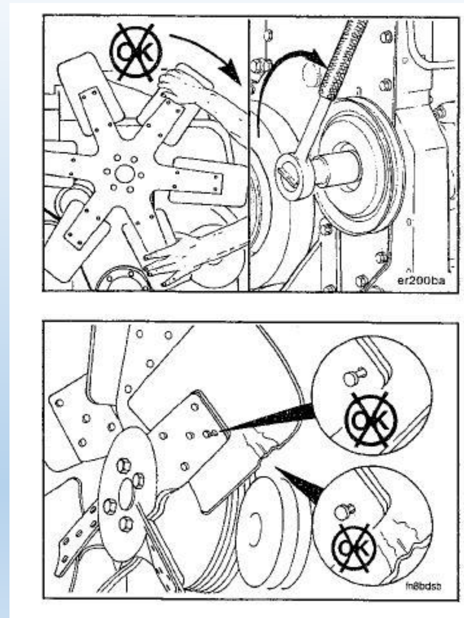
Visually inspection is required to check for cracks, loose rivets and bent or loose blades.

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.

Fan, Cooling

Do not straighten a bent fan blade or continue to use a damaged fan, It may fail and cause personal injury.

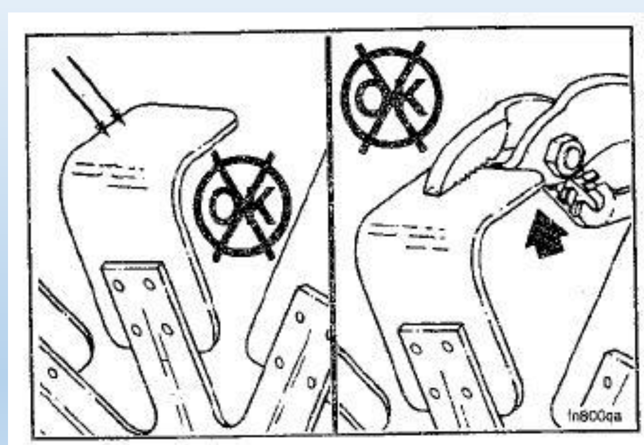
Replace original equipment fan that is damaged with a fan of the identical part number.



Fan, Cooling

Do not straighten a bent fan blade or continue to use a damaged fan, It may fail and cause personal injury.

Replace original equipment fan that is damaged with a fan of the identical part number.



Crankcase Breather Tube

- Inspect the breather tube for sludge, debris etc.

Crankcase Breather Tube

- Inspect the breather tube for sludge, debris etc.

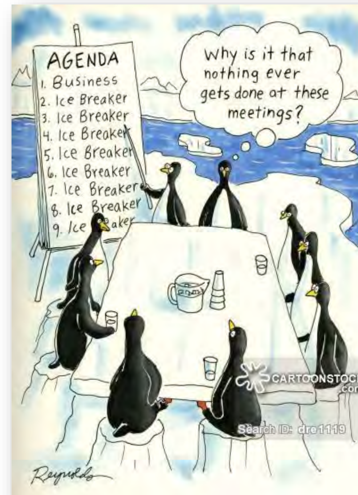
O & M of Mechanical and Electrical Equipment
WSD 5231

Introduction to SCADA System

Module 6, Lecture 1

Agenda

1. Introduction
2. Need for SCADA
3. SCADA Functions
4. System Equipment
5. Operation of SCADA System
6. Usage of SCADA in water utility sector
7. Case Study WASA, PMU Faisalabad

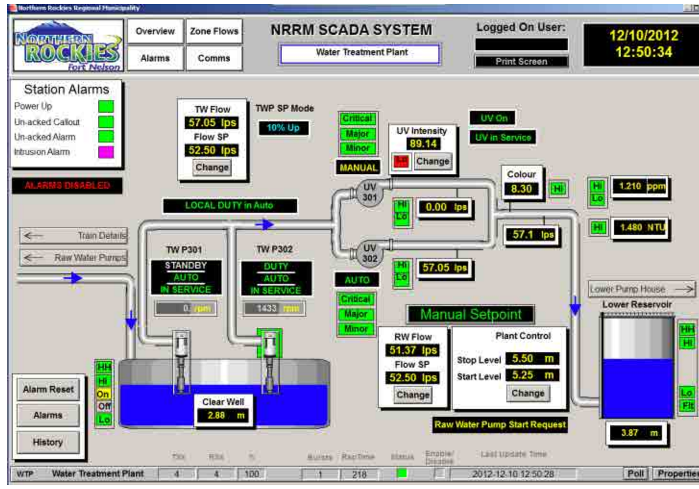


Introduction

- Importance automated supervisory control in water utility sector
- What do we cover in this module?
- What to expect in this module?
- Goal and objectives of this module?

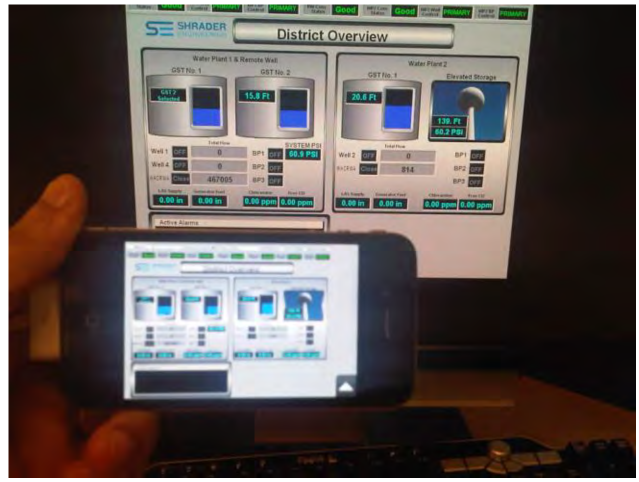
Introduction

- SCADA" stands for “Supervisory Control and Data Acquisition."
- The SCADA system is essentially a distributed computer system that is used by operations and management for real time process monitoring and control.



Need for SCADA System

- Reduce operating costs
- Improving system performance and reliability
- Targeting Non-Revenue Water
- Water Security (Theft control)
- Automatic monitoring and data logging
- Real time system parameters

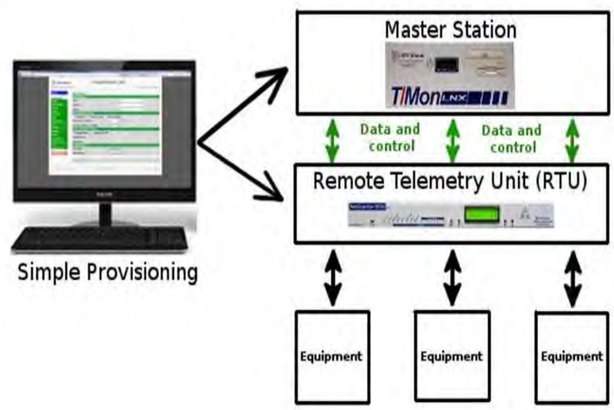


Need for SCADA System

Automation → Increase in efficiency → Decrease in cost

SCADA system architecture

- SCADA Master
- Remote Terminal Unit (RTU)
- Sensors
- Valves
- Control Relays



SCADA functions

- Data acquisition
- Data Communication
- Data Presentation
- Control

Data acquisition

- It is the process of acquiring real time continuous data from all remote units installed, feeding it to each RTU for processing, transmission and presentation

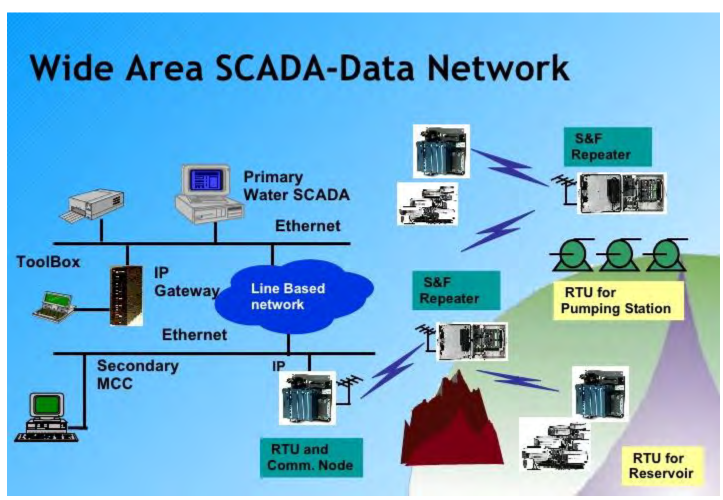
- Sensors monitor Inputs and outputs.

- Types of Input
  - ✓Discrete Inputs
  - ✓Analogue Inputs

Data Communication

- Communication channel between RTU and the Master SCADA.

- SCADA networks communicated over radio, modem or dedicated serial lines. These days the trend is to put SCADA data on Ethernet, Microwave and Optical fiber

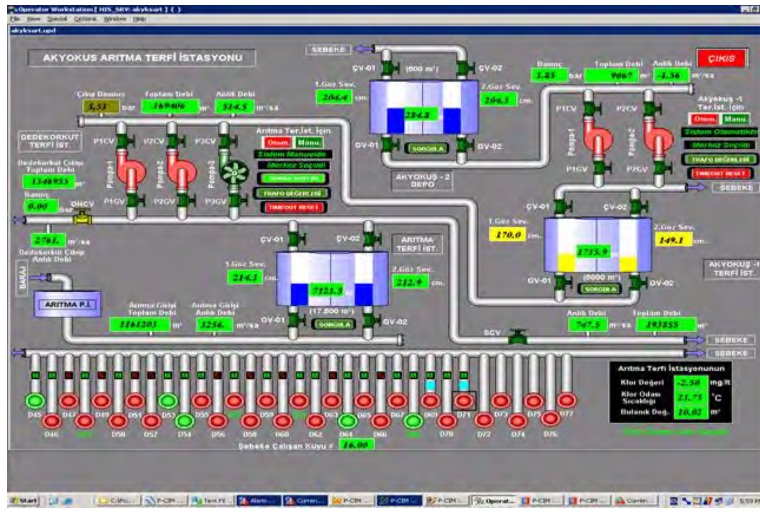


Data Presentation

- SCADA systems report to human operators over a master station.
- Functions:

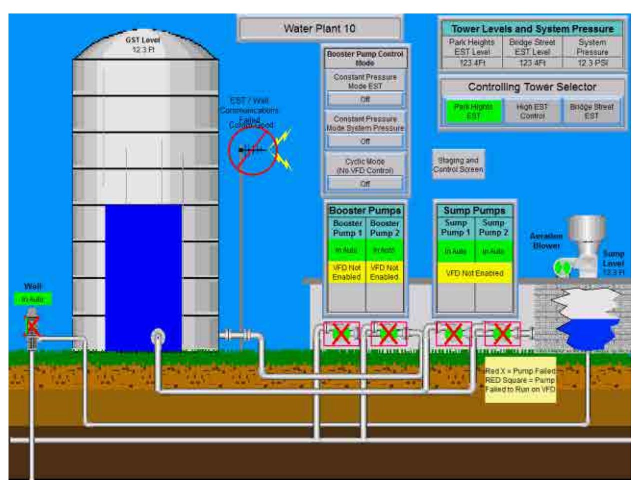
✓ Continuously monitors all sensors and alerts the operator when there is an alarm.

✓Presents a comprehensive graphical view of the entire system.



Control

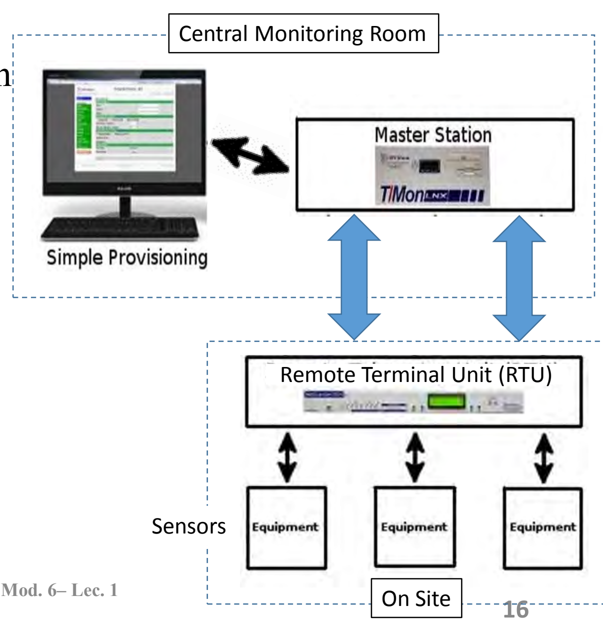
- In a SCADA system the control is with the Master SCADA which serves as the brain of this system.
- Master SCADA HMI commands the respective RTU to perform a specific action.



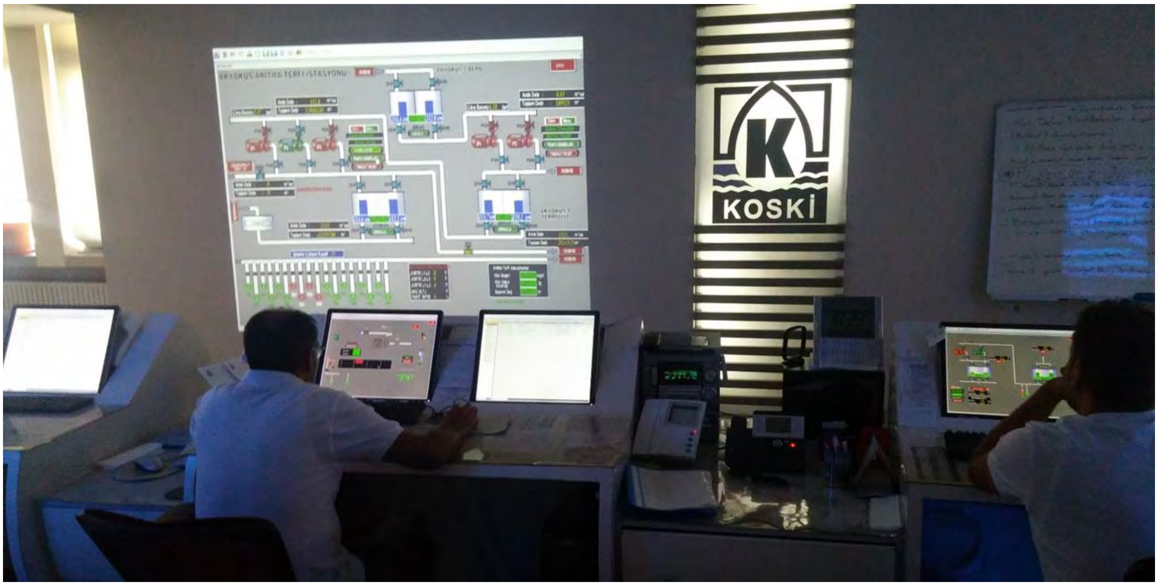
System Equipment

Following are the four main categories in which system equipment

- SCADA Master & Human Machine Interface
- Communication Network
- RTU's (Remote Terminal Unit)
- Sensors & Control Relays (Discrete / Analogue)

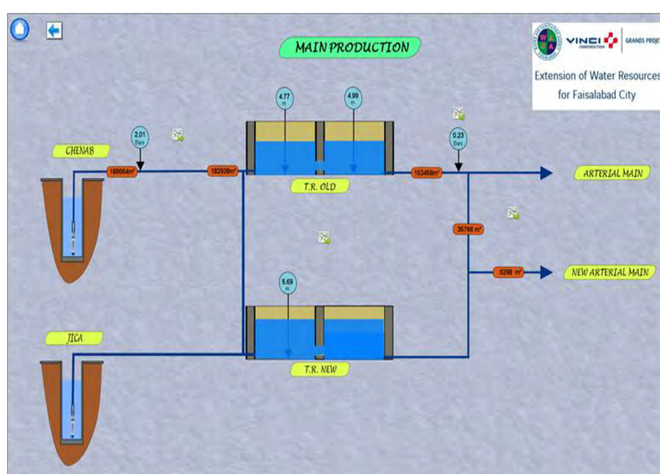


SCADA Master & Human Machine Interface



SCADA Master & Human Machine Interface(HMI)

- SCADA Master collects data from each site, processes it and displays it on the HMI in a user friendly way
- HMI is an interface which presents processed data to a human operator, and through this, the human operator monitors and controls the process.



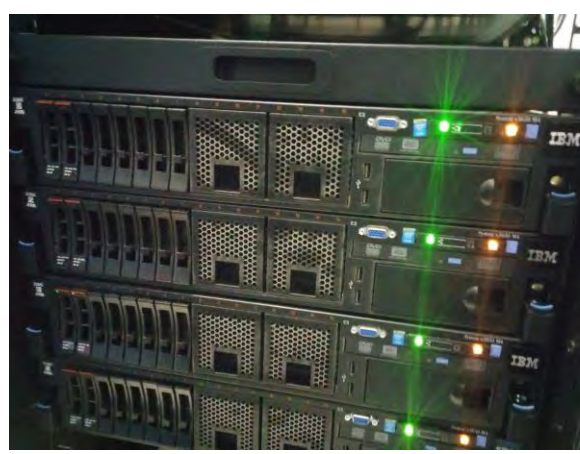
SCADA Master & Human Machine Interface(HMI)

What to look for in SCADA Master

- Display information in a useful and clear way
- Programmable Controls
- Multi-Protocol and Equipment support (future advancements)
- 24/7 Email and SMS notifications

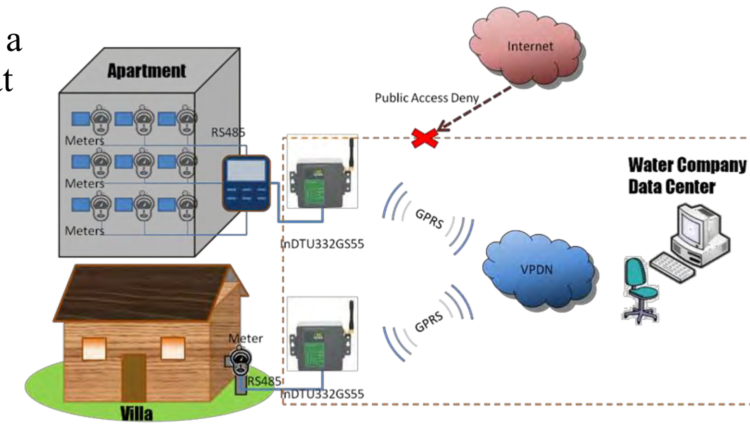
SCADA Hardware

- Servers (Total 8, 4 online 4 backup)

Communication Network

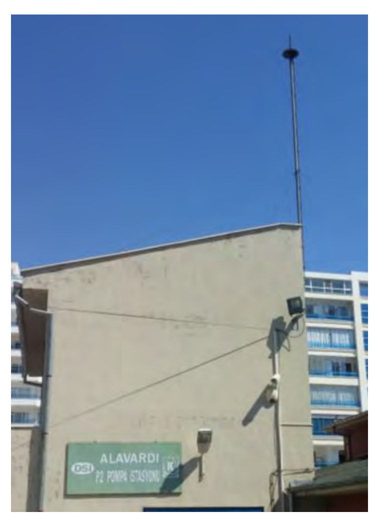
- Communication network is a communication channel that connects each RTU to the SCADA Master. It can be optical fiber, Ethernet or microwave.



Communication Network

- Base station antennas

- Remote station antenna



RTU’s (Remote Terminal Unit)

- It connects to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory system (SCADA Master).

RTU’s (Remote Terminal Unit)

- What to look for while selective RTU?

- Just Right Capacity
- Intelligent Control
- Rugged Construction
- Redundant Power and Communication

RTU’s (Remote Terminal Unit)

- MOTOROLA ACE-4600 REMOTE TERMINAL UNIT

Sensors & Control Relays (Discrete / Analogue)

- These are used to gather real time data / signals and to control the state of pumps and valves

Operation of SCADA system

- Monitoring and processing of data

✓Monitor, gather, and process data

✓Interact with and control machines and devices such as valves, pumps, motors which are connected to HMI

✓Record events into a log file

Advantages of SCADA system for Water Utility

Increase in Efficiency by:

- Minimizing Fault Response Time.
- Isolate and Precisely Locate Faults
- Water security and to monitor water theft.
- Bridge gap between supply and demand.
- Automation at tube-well station can optimize operations
- It provides real time data of a complete process plant on a single computer screen.

Advantages of SCADA system

- Control Non-Revenue Water
- Costly after-hours alarm call-outs can often be avoided since a SCADA system will indicate the nature and degree of a problem
- Hundreds of log sheets of any data recorded on the SCADA system can be downloaded and accessed at their convenience.
- SCADA systems can often be accessed remotely through an internet connection on your office computer or laptop, and even your cell phone or tablet.

General Application of SCADA

- **Electric power generation, transmission and distribution**:

Electric utilities use SCADA systems to detect current flow and line voltage, to monitor the operation of circuit breakers, and to take sections of the power grid on or offline.

- **Buildings, facilities and environments**:

Facility managers use SCADA to control HVAC, refrigeration units, lighting and entry systems.

- **Manufacturing**:

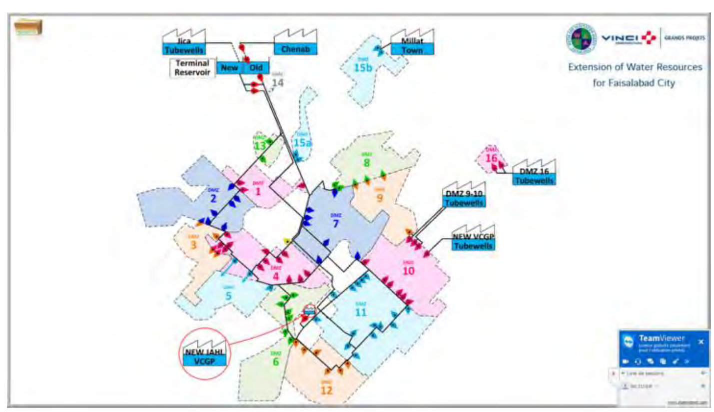
SCADA systems is used for assembly line, regulate industrial automation and monitor process and quality control.

- **Traffic signals**:

SCADA regulates traffic lights, controls traffic flow and detects out-of-order signals

Case Study

- SCADA System Installation & Operation at PMU, WASA Faisalabad.



Wrap-up

- Automation is the future.

OJT

Operation and Maintenance of Mechanical & Electrical Equipment

Health Safety & Environment for Electrical Components

Activities for On-the-Job Training

1. Electrical Panel
2. Generator
3. SCADA System

- Hazard Hunting
- Job safety analysis (JSA)
- Fire Fighting
- Electric Shock
- Electrical Safety Rules
- Accident and Incident Reporting

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.

Hazard Hunting

Hazard Category

- **Safety: Related to safe O&M**
- **Health: Related to protection of health of employee**
- **Environment: Related to natural / man made losses**
- **Technology: Accident / incidents related to operations etc.**
- **Behavior: Reaction of employee to working conditions**

5/31

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

6/31

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 bite (SCADA Panel)	Sealing of Casing	Electrician	10.12.2016	Delayed

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

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.

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

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

13/31

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

14/31

Example : Electrical Facility - Job Safety Analysis (JSA)

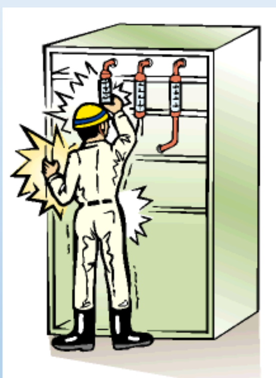
Location:	Tube well 4-D1, Green Town Sub Division
Date:	December 9th, 2016
Conducted By:	Sub Engineer, Electrician and Tube well Operator

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.

15/31

Major hazards related to Electrical Facility



Electric shock

Electric fire

16/31

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

17/31

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

18/31

Fire Fighting

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

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

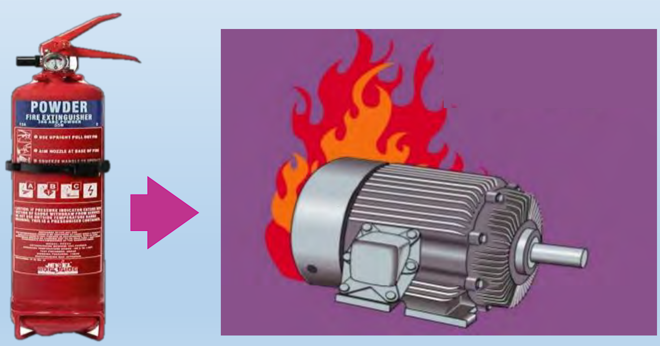

Electrical Fire Safety

☠Do not use water to Extinguish electrical fire

21/31

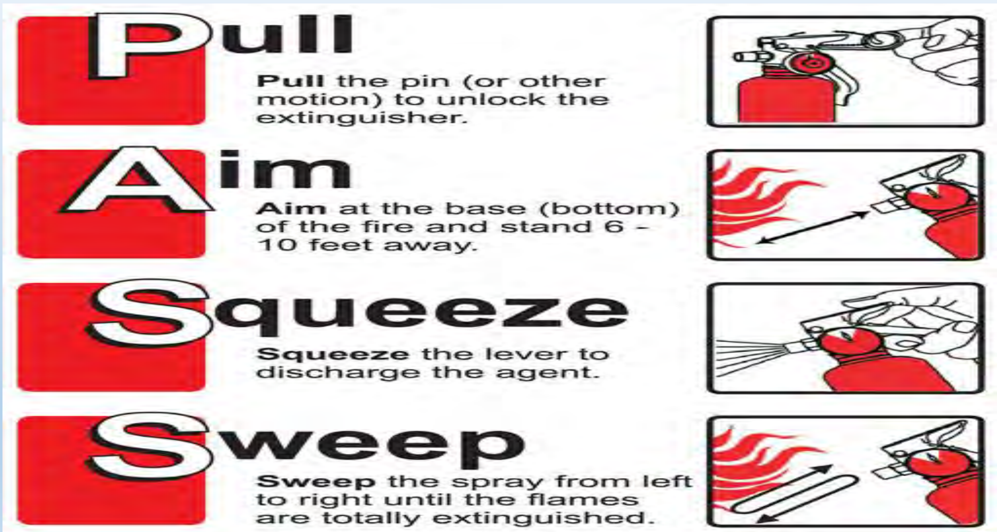
Always remember

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



22/31

Steps of using fire Extinguisher



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 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 affectee**

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
- If the victim has a burn, remove any clothing that comes off easily & rinse the burned area in cool running water until the pain subsides
- Call RESUE 1122

25/31

Electric Shock Video

26/31

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 working with electrical components

27/31

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

28/31

First Aid Box

Accessories

- Panadol or Paracetamol
- Dichloron
- Sterile gauze pads of different sizes
- Adhesive tape
- Adhesive bandages of several sizes
- Elastic bandage
- Splints
- Antiseptic wipes
- Antibiotic ointment
- Antiseptic solution
- Tweezers
- Sharp scissors
- Safety pins
- Thermometer
- Antihistamine tablets
- Distilled water for cleaning wounds or burns
- Eye wash

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..

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

31/31

Annex 3.23

Training Material for O&M of Mechanical Equipment

in Fall 2016

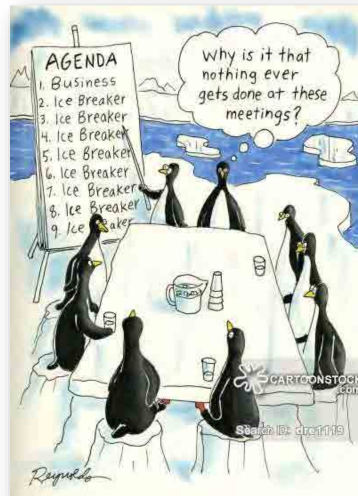
O & M of Mechanical and Electrical Equipment
WSD 5231

3-Phase Induction Motors

Module 1, Lecture 2

Agenda

1. Ice Breaker and Class Introduction
2. Resources and handouts
3. Introduction of motors
4. Basic design and construction
5. Motor burnout and rewinding
6. Efficiency for re-wound motors
7. Troubleshooting



Icebreaker and Class Introduction

- Importance of motors 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 electro-mechanical equipment?

Icebreaker and Class Introduction

Now it is your turn…

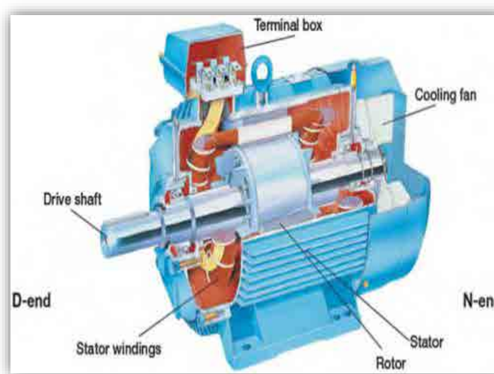
- Any prior experience on induction motors?
- Why interested in this module?
- What best skills do you bring to the class?

Resources and Handouts

- Electrical Fundamentals for Water and Wastewater,
  Arasmith, S. DeRamus, H. 2010
- http://www.industry.siemens.com/drives/global/en/motor
- http://www.electrical4u.com
- Siemens owner's manual
- Participant lecture notes, Module 1, Lecture 2
- Class presentations

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.

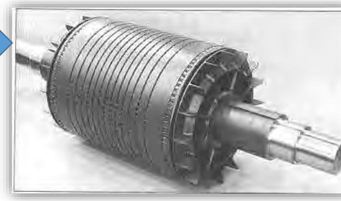


Basic Design and Construction

An induction motor has two main components:

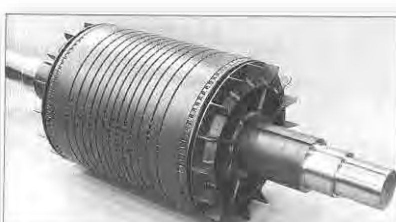
1. (Stationary part) Stator

2. (Revolving part) Rotor



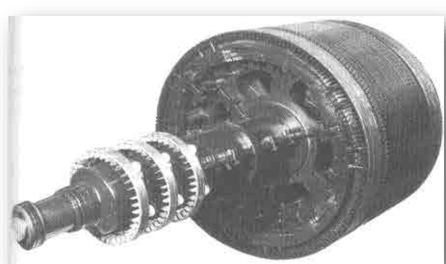
Basic Design and Construction

Rotor Types



Squirrel cage rotor

Slip ring rotor

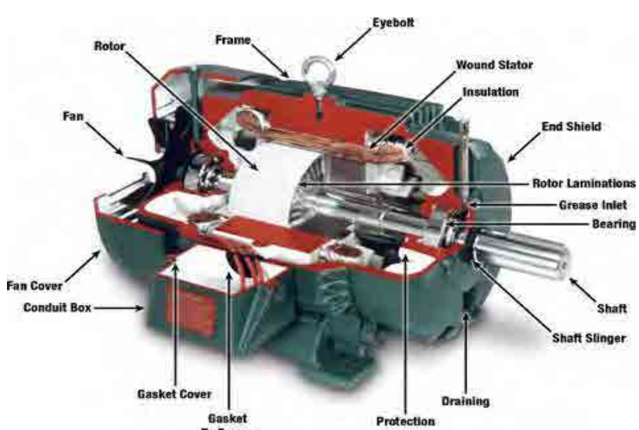


Basic Design and Construction

Terminals

Basic Design and Construction

Section View



Basic Design and Construction

Basic Design and Construction

Slip of an induction motor…

- Induction motor rotor always rotate at a speed less than synchronous speed.
- The difference between the flux (Ns) and the rotor speed (N) is called slip.
- % Slip (s) = (Ns – N)/Ns *100
- Where Ns=Synchronous Speed N= Actual Speed of rotor
- Slip speed = Ns – N

Motor Burnout and Rewinding

Causes…

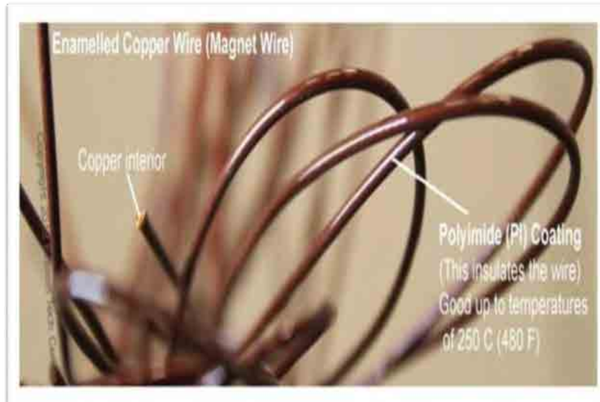
1. Fluctuation in phase voltages
2. Manufacturing defects
3. Damage before or during installation
4. Improper installation
5. Misapplication (overload)

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

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

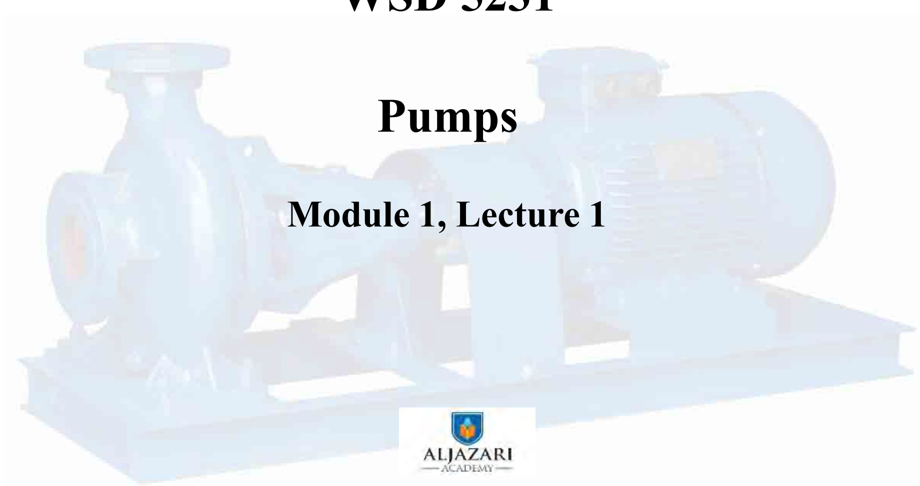
Wrap-up

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 !!!

Troubleshooting

O & M of Mechanical and Electrical Equipment
WSD 5231



Pumps

Module 1, Lecture 1

Topics to cover..

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

Topics to cover..

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

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 WASA equipment?

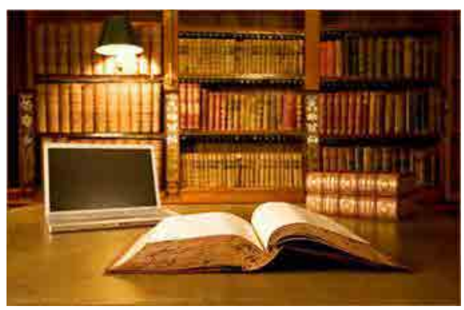
Brainstorming

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

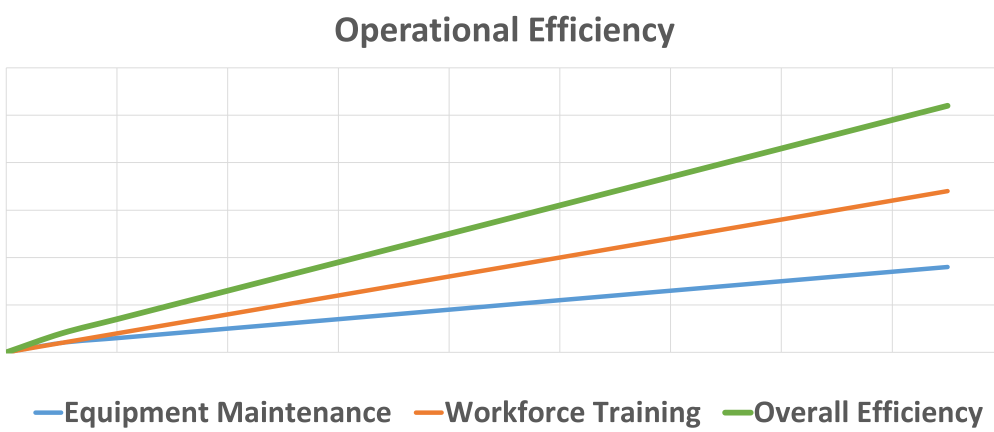
Importance of Disposal Station Pumps

This could be our children !

Importance of Tube Well Pumps

This could be my home !

Importance of Equipment and Skills



Introduction to Pumps

Pump

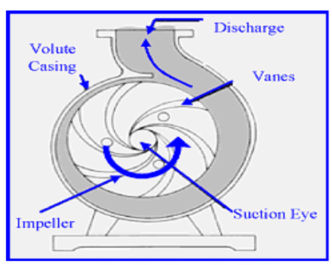
It is a mechanical device to transport liquids. It coverts kinetic energy into velocity/pressure.

Introduction to Pumps

Two major categories:

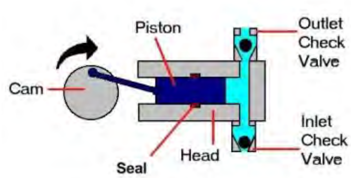
i) Centrifugal Pumps

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.



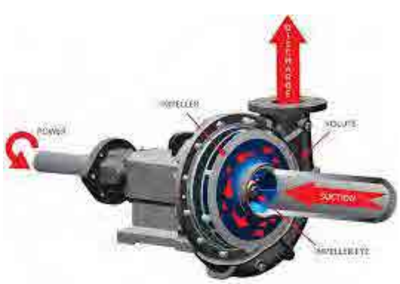
SINGLE ACTING RECIPROCATING

Introduction to Pumps (Disposal Station)

Introduction to Pumps

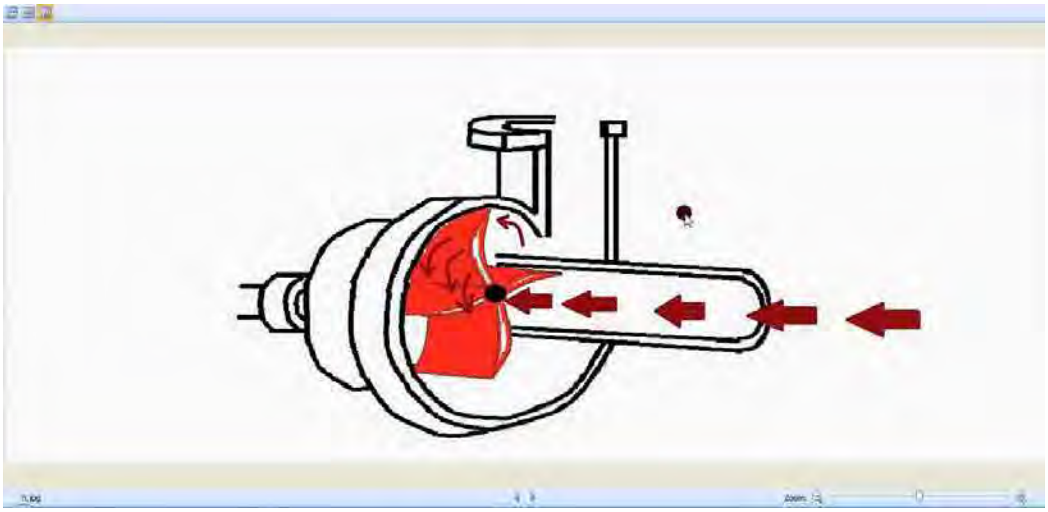
Centrifugal Pumps

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?

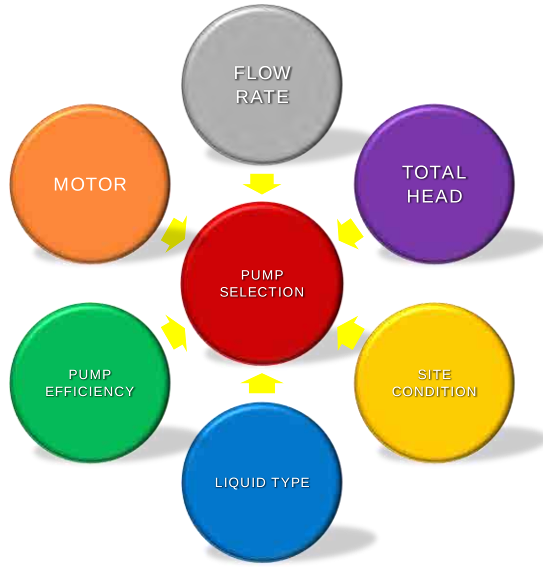
How far or high water will be delivered?

Is there a guaranteed pump efficiency need?

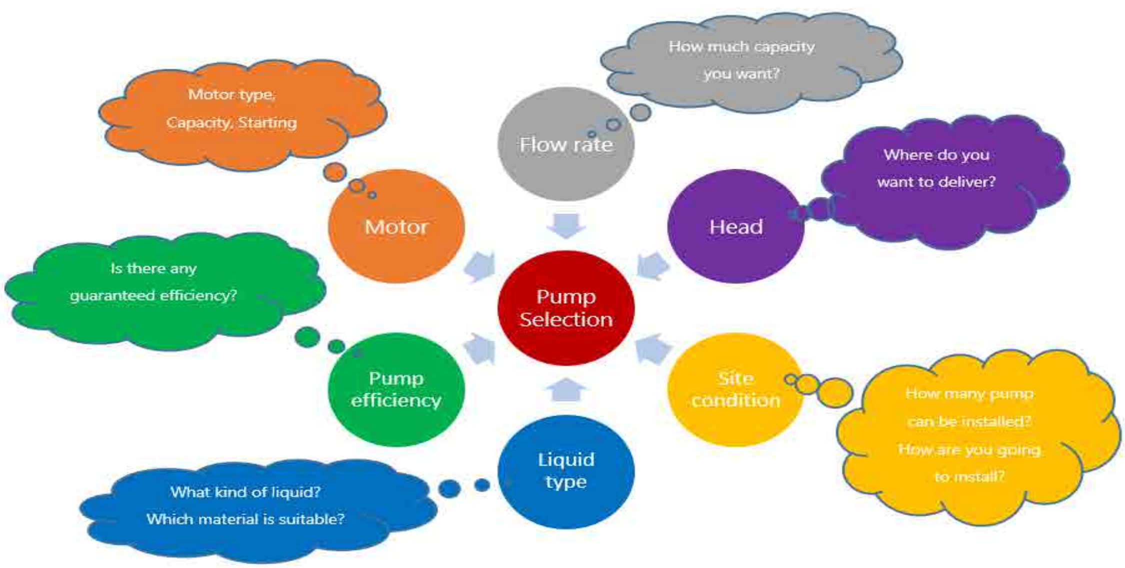
What kind of liquid is transported?

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

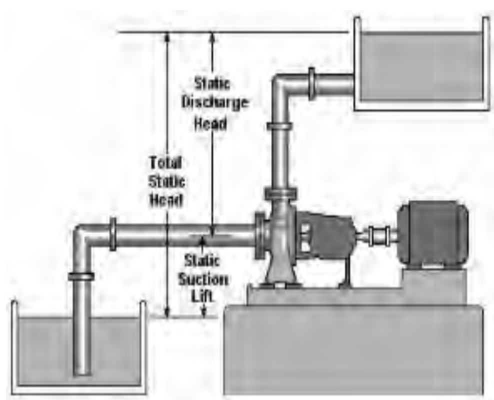
The following terms apply specifically to the analysis of pumps and pumping systems:

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

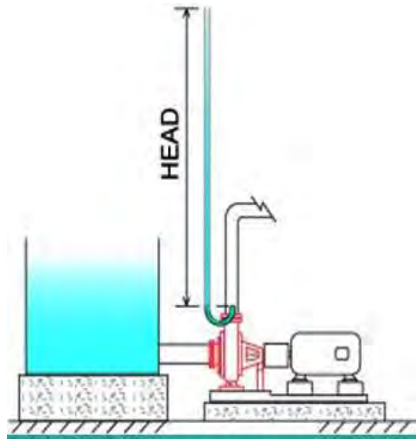
The term "head" is the elevation of free water surface of water above or below a reference datum. For example, if a small, open-ended tube were run vertically upward from a pipe under pressure, the head would be the distance from the center line of the pipe to the free water surface in the vertical tube.



Introduction to Pump Design Basics

Head

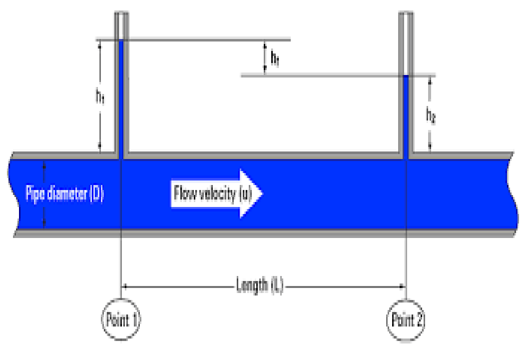
In pumping systems, the head refers to both pumps and pumping systems. The height to which a pump can raise the water is the pump head and it is measured in meters (feet) of flowing water. The head required to overcome the losses in a pipe system at a given flow rate is called the system head.



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

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

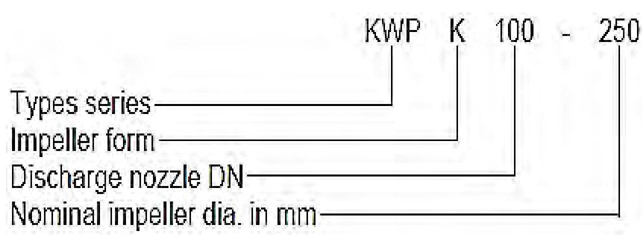
Specification:

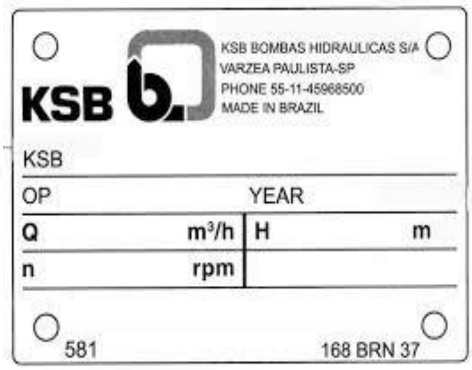
Discharge Diameter: 40--500mm(1.6--20inch)

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

Head: 6--80m

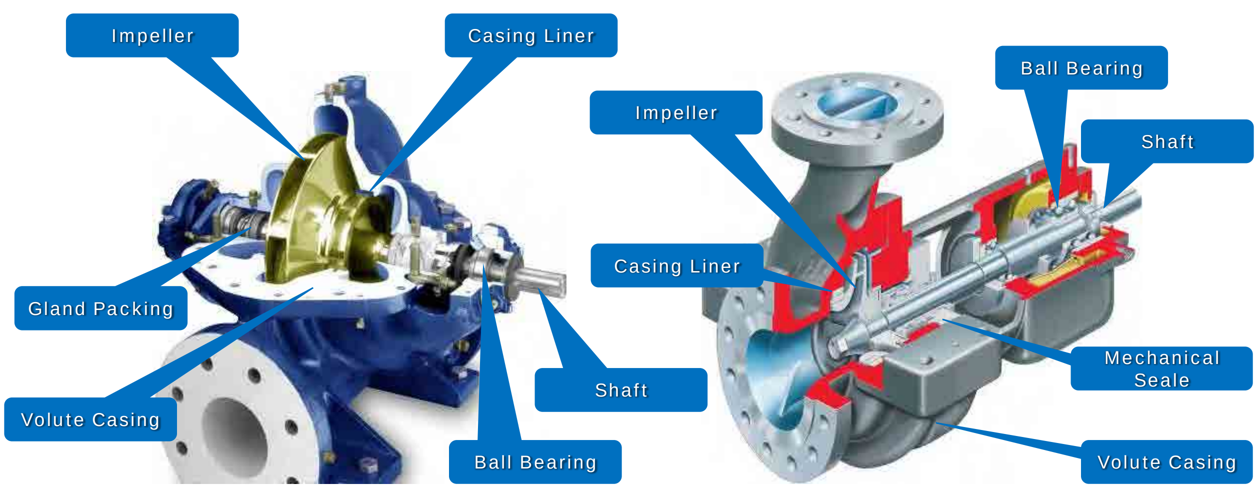
Name Plate and Designation





Assembly Parts of Pumps

Centrifugal Pump Structural Parts for Disposal Station



Double Suction Volute Pump

Single Suction Volute Pump

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

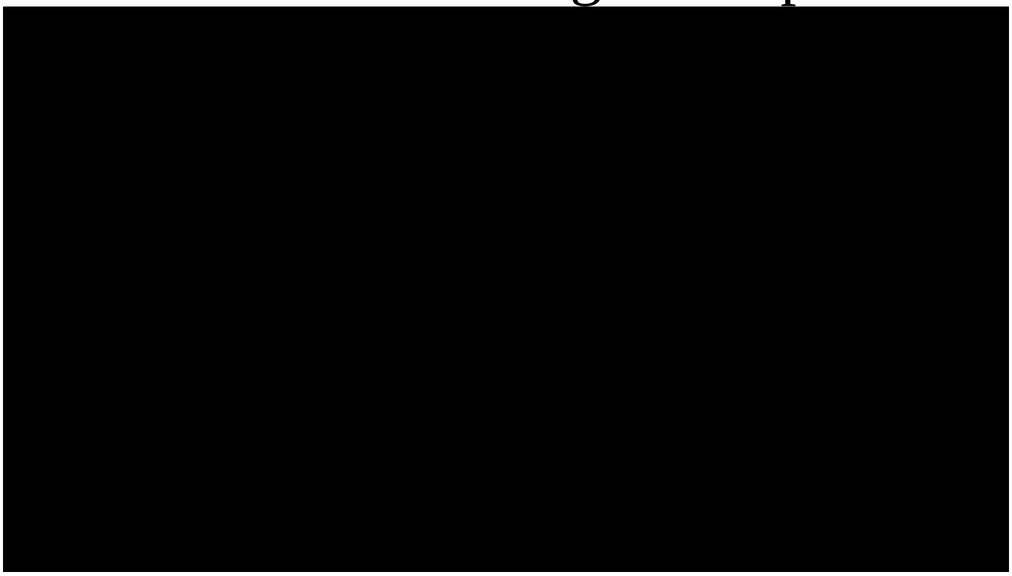
- Check that ammeter reading is less than rated motor current
- After startup check sump level (stable)
- Check for undue vibration and noise.
- After10-15 minutes, check the bearing temperature, stuffing box packing, and leakage through mechanical seal.
- Voltage should be checked every hour.

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

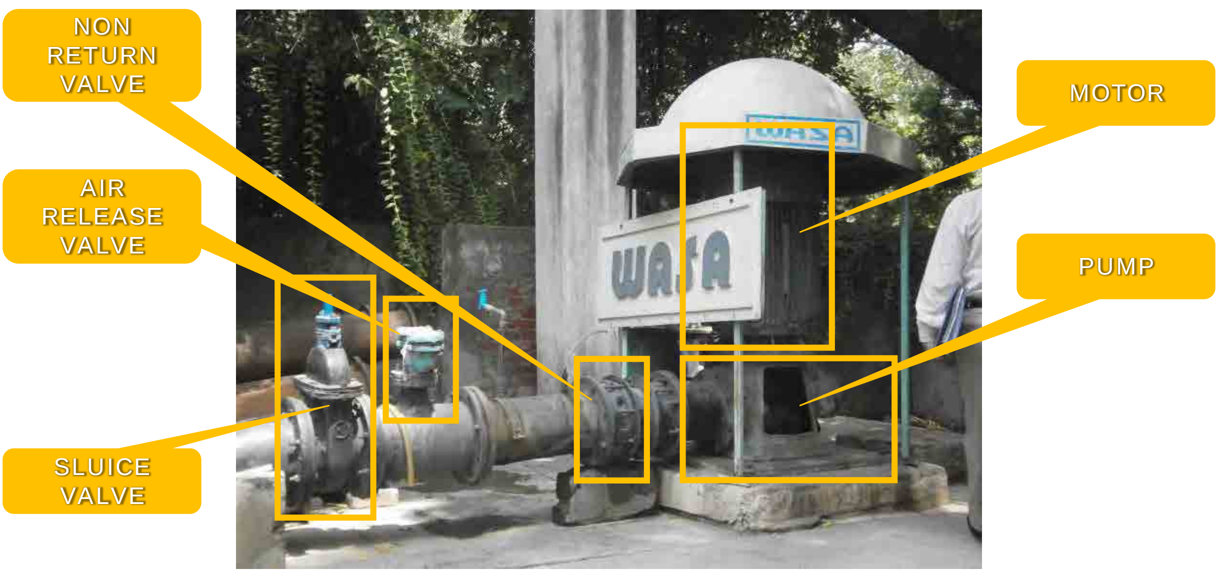
Video Centrifugal Pumps



WSD 5231, Module 1

39

Introduction to Pumps (Tube Well)



WSD 5231, Module 1

40

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

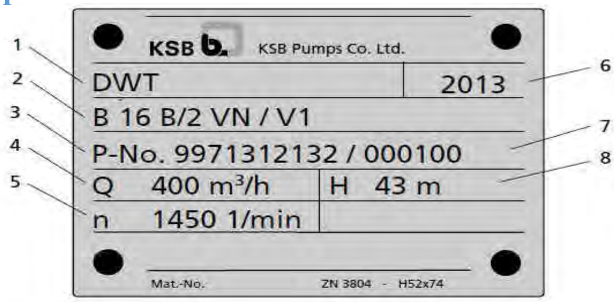
DesignationExample: B 16 B/2 VN / V1

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



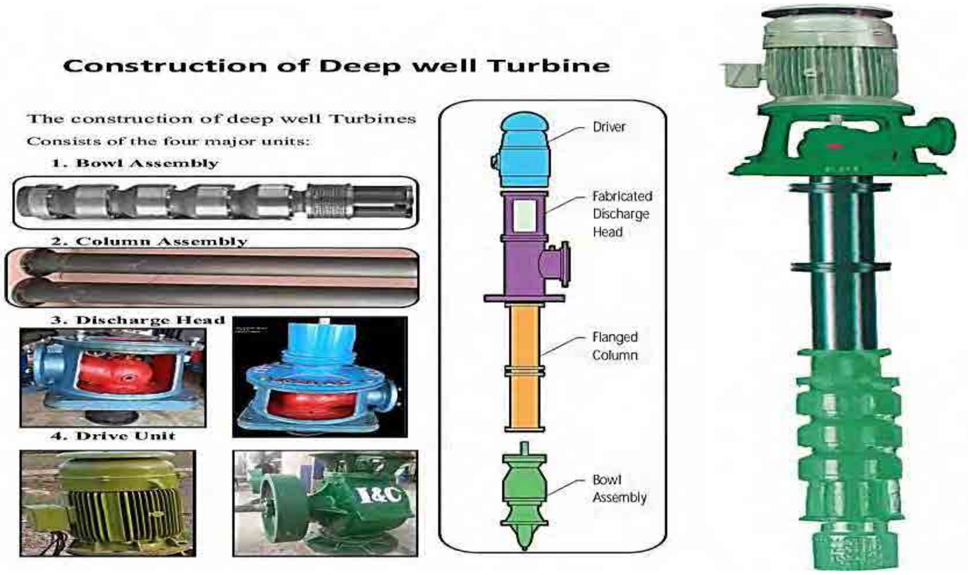
1	Pump type	2	Designation of the pump set
3	Order number	4	Flow rate
5	Speed	6	Year of supply
7	Order item number	8	Head

Introduction to Pumps Types

Submersible Pump

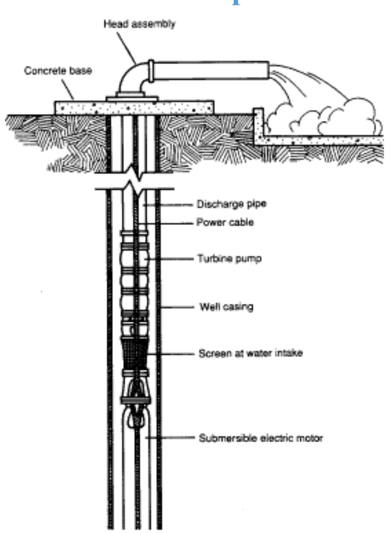
A type of pump in which the motor and pump both are in the ground water reservoir. Motor is water proof and electricity is provided to the motor by a water proof cable.

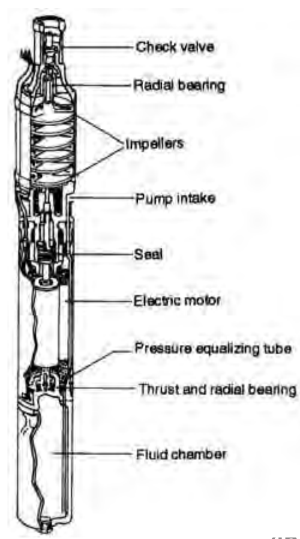
Assembly Parts of Pumps



Assembly Parts of Pumps

Structural Parts of Submersible Pump for Tube well





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

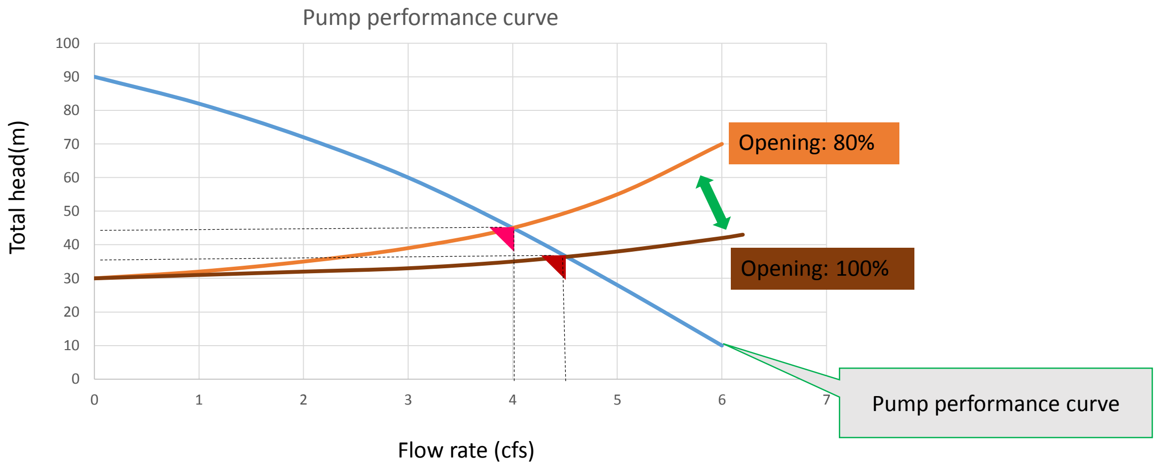
- After startup check pressure for operating point.
- Check for undue vibration and noise.
- After10-15 minutes, check the bearing temperature, stuffing box packing, and leakage through mechanical seal.
- Voltage should be checked every hour.

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 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).

Troubleshooting

Trouble shooting Pump

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.

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

O & M of Mechanical and Electrical Equipment
WSD 5231

Valves

Module 1, Lecture 3

ALJAZARI ACADEMY

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 operation
- ✓ 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?

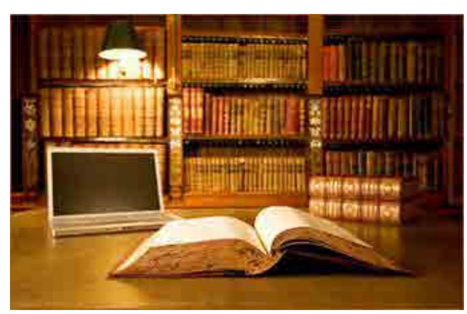
Icebreaker and Class Introduction

Now it is your turn…

- Any prior experience on valves?
- Why interested in this module?
- What relarive skills do you bring to the class?

Resources and Handouts

- MANUAL OF WATER SUPPLY PRACTICES—M44, Second Edition Distribution Valves: Selection, Installation, Field Testing, and Mainteannce 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 Dehli

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

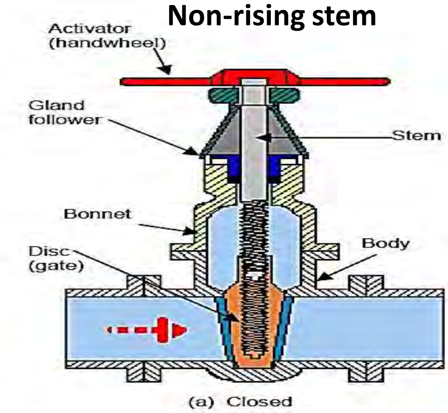
Valve types	Linear motion	Rotary motion	Quarter turn
Gate Valve	x		
Air release valve	x		
Butterfly valve		x	x
Non-return valve		x	x
Flap valve		x	

Assembly parts of valves

Basic Parts of the valve

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

Non-rising stem



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

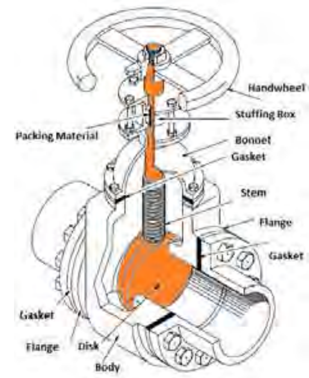
Body

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

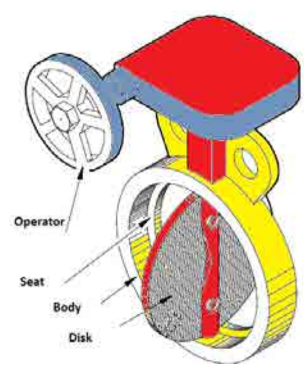
Methods of controlling flow through a valve.

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



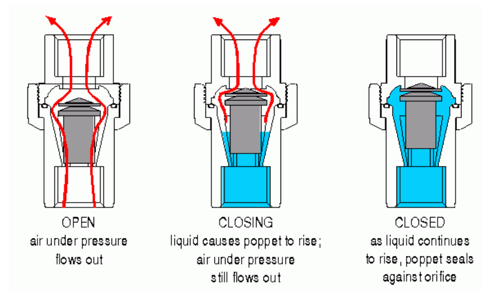
Gate valve

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



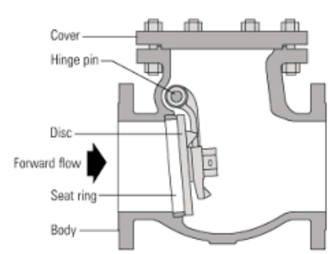
Butterfly valve

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



Air release valve

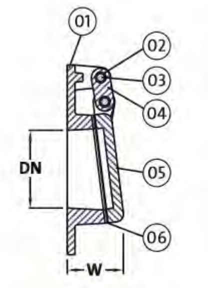
4. Non return valve rotates a disc to stop the backflow of the fluid



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.

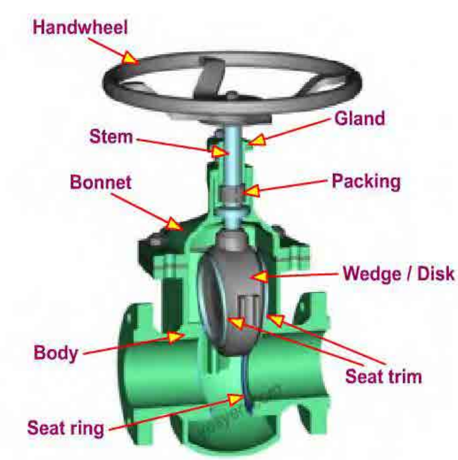
H. Speed of closure.

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.

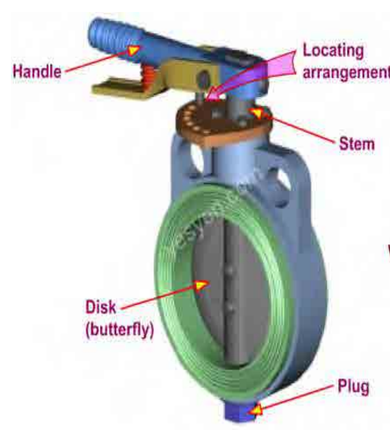
- It is prone to vibration in the partially open state.
- It is more subject to seat and disk wear.
- Repairs, such as lapping and grinding, are generally more difficult to accomplish.

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

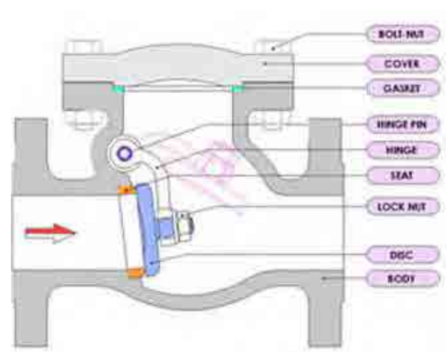
- Difficult to clean
- Throttling limited to low differential pressure
- Potential for cavitation and choke
- Unguided disc movement is affected by flow turbulence

Introduction and selection of valves

Valve Types

Check or Non return valve

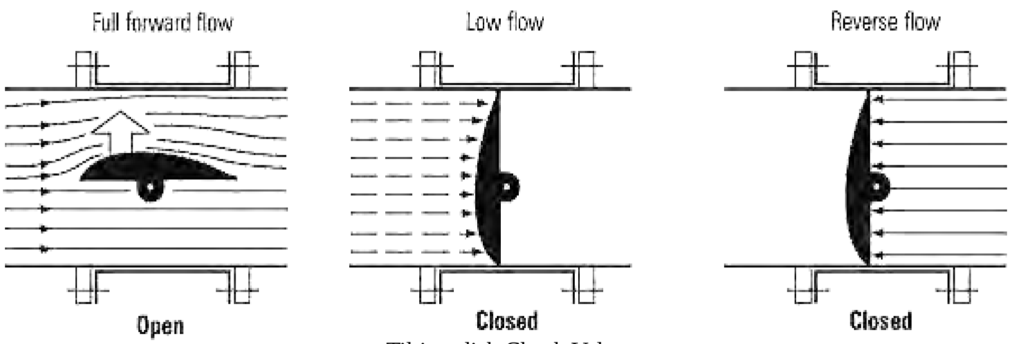
Check valves are designed to prevent the reversal of flow in a piping system. These valves are activated by the flowing material in the pipeline. The pressure of the fluid passing through the system opens the valve, while any reversal of flow will close the valve.



Introduction and selection of valves

Valve Types

Check or Non return valve



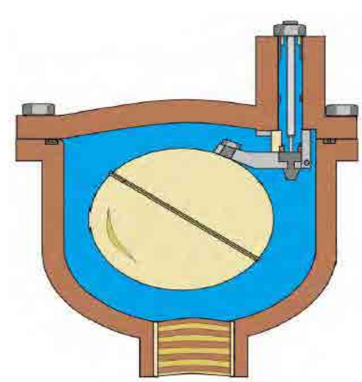
Tilting-disk Check Valve

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

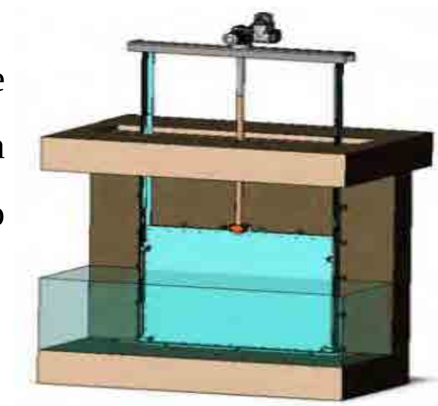
- If a pipeline is filled or emptied too quickly, an air release valve does not always keep up with the air flow demands.
- You must size the valve correctly for your application.

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 and Electrical Equipment
WSD 5231

Chlorination and Filtration System

Module 4, Lecture 1

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?

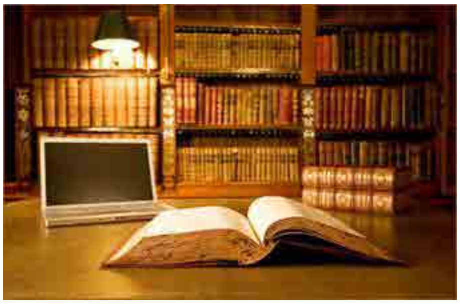
Icebreaker and Class Introduction

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

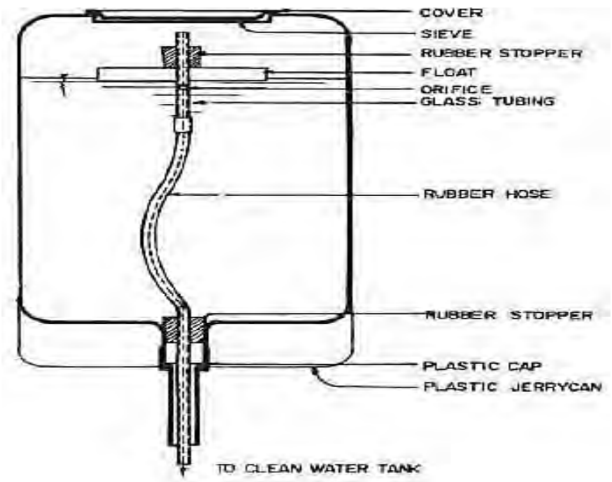
The hypo-chlorinator is a pump used to add hypochlorite solutions to water at a manually adjustable feeding rate. Pump draws the hypochlorite solution from a container and transfers it into the water for treatment.

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)

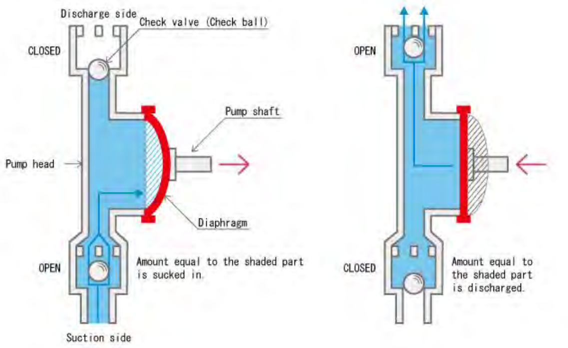
Diaphragm pump in chlorinator

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)

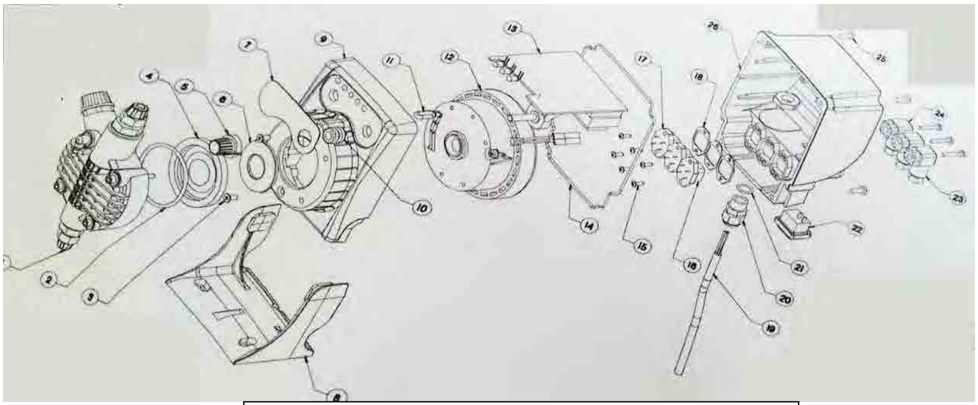
Diaphragm pump properties:

- 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:

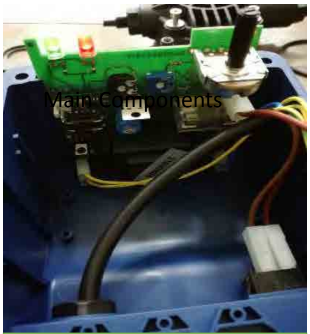
S.No's	Names of Parts	S.No's	Names of Parts	S.No's	Names of Parts
1	Pump Head	10	Potentiometer Gasket	19	Power Cable
2	Pump Head O-ring	11	Thermostat	20	Cable Clamp
3	Electromagnet screw	12	Electromagnet	21	Cable Clamp O-Ring
4	PTFE Diaphragm	13	PC Board	22	Switch
5	Pulse Adjusting Knob	14	Back Cover 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

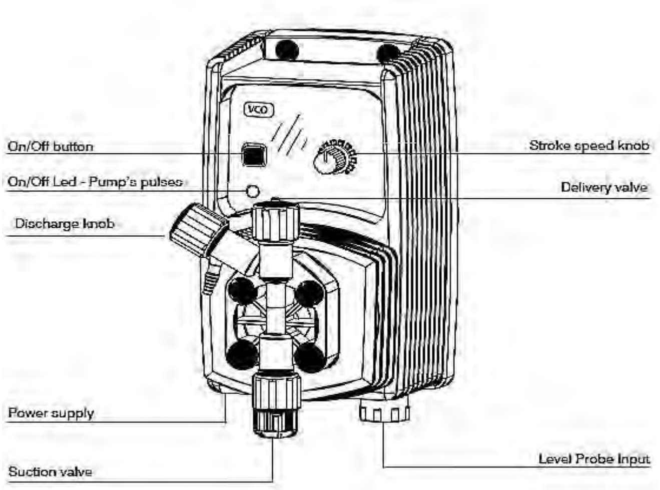
WASA use different types feed pumps for chlorine supply, most common are

a) EMEC V Pump

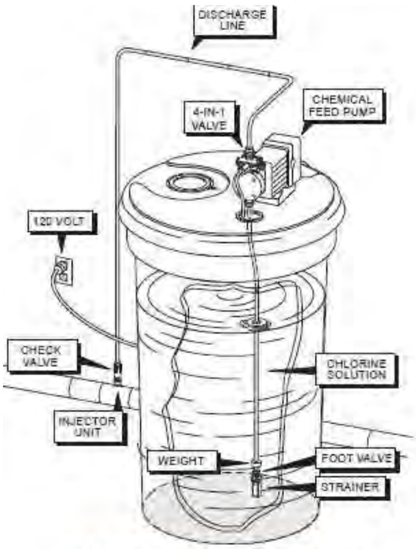
b) CHEM TECH Pump

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.

<u>Attention:</u>

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

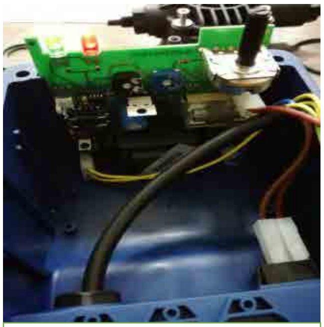
Electrical Faults for Chlorinator EMEC V Pump

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.	7.0----------9.2	
3	Adour.	Unobjectionable	
4	Colour.	5---------50 Units	
5	Taste.	Unobjectionable	
6	Turbidity	0--------5 NTU	
7	Clay/Sand/Rust.	Absent.	
8	Conductivity. µs/cm	------------------	
9	Total Dissolved Solid. mg/L	500--------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 → Refer to the Existing Water Supply System → Identify Hazard → Prioritize the Outcomes → Develop Water Safety Plan → Monitor the Control Measures

WSD 5231, Mod 1

41

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

WSD 5231, Mod 1

42

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

WSD 5231, Mod 1

45

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

WSD 5231, Mod 1

46

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 Responsibilit y
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.

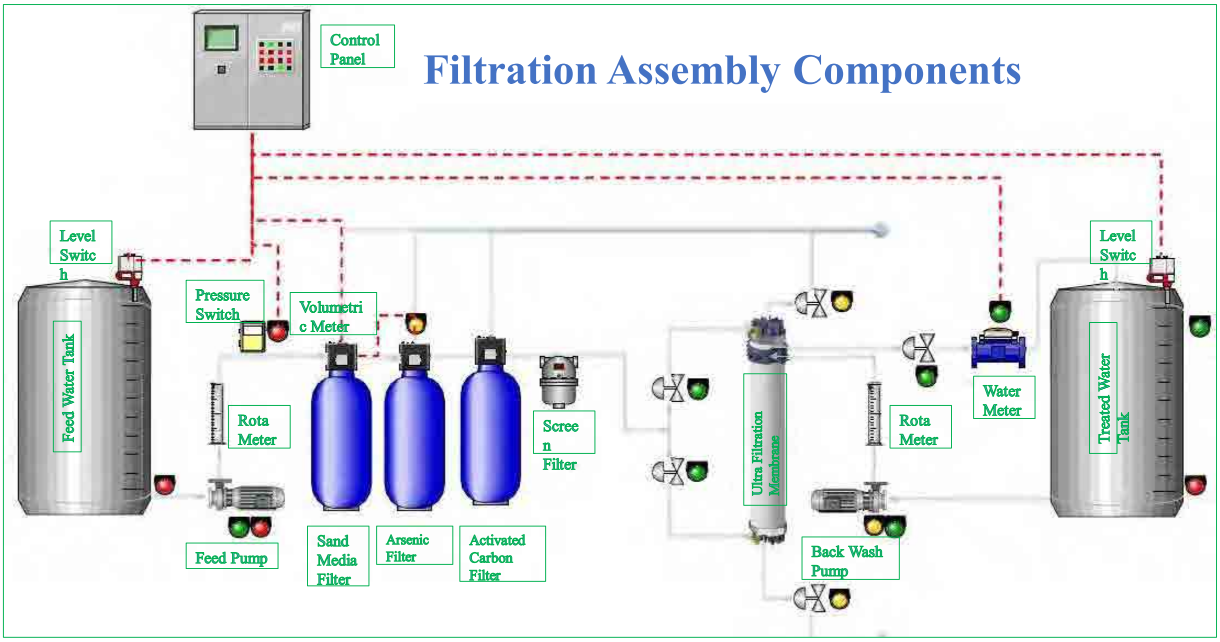
Importance of Filtration Systems.

Importance of Filtration system at WASA tube well

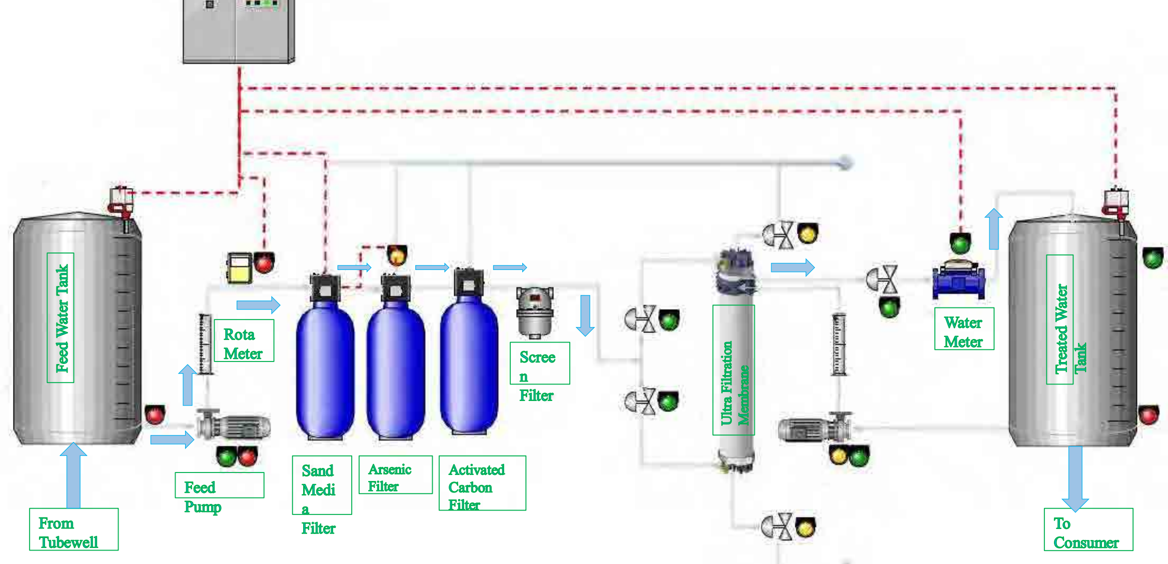
- In LDA – WASA Lahore Project the water filtration process is designed to remove pollutants which are Turbidity, Bacteria, Arsenic and heavy metals.
- Raw water will feed to Raw Water Storage Tank capacity 2,000 liter.
- Each plant has capacity of 4000 LPH.
- The water treatment process will start from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

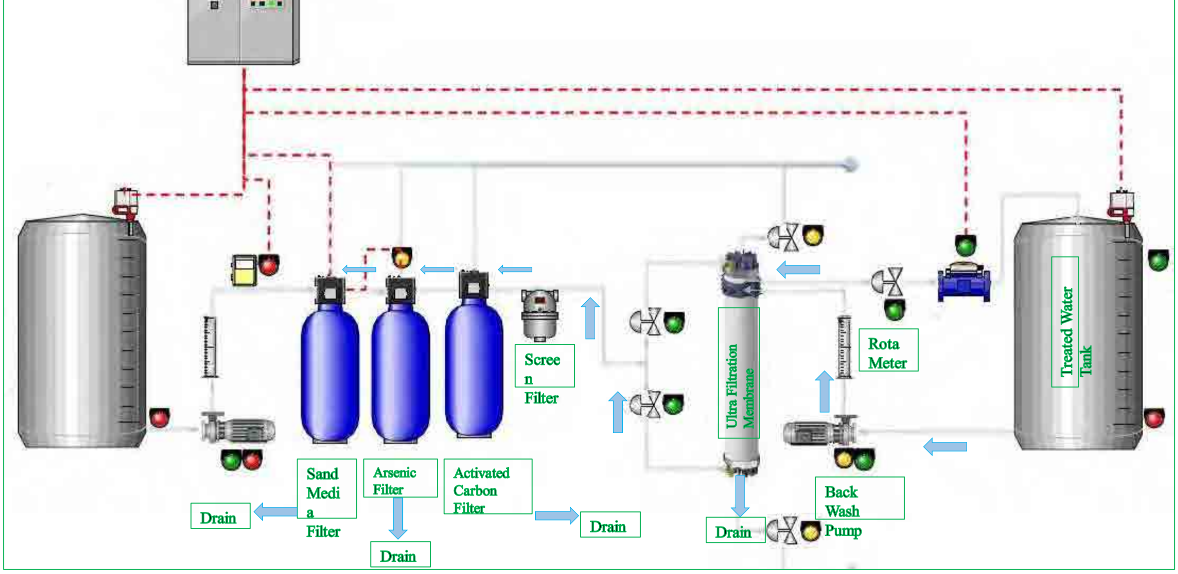


Filtration Feed Process



WSD 5231, Mod 1 57

Filtration Back Wash Process



WSD 5231, Mod 1 58

Operation of Filtration system

Operation of Tube well 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 and Electrical Equipment
WSD 5231

Heavy Machines

Module 5

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?

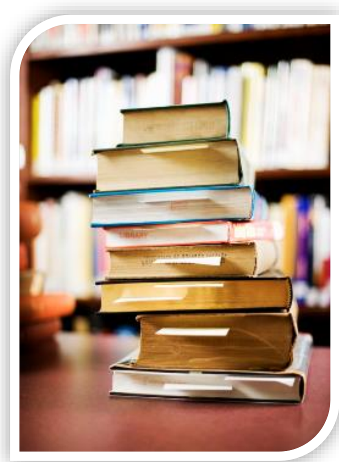
Now it is your turn…

- 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?

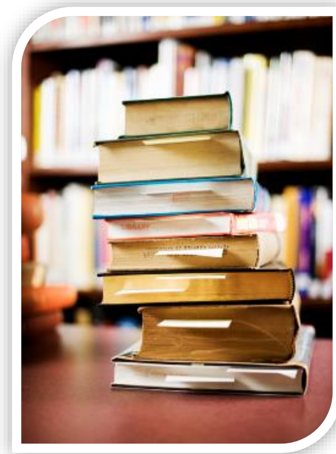
Resources and Handouts

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

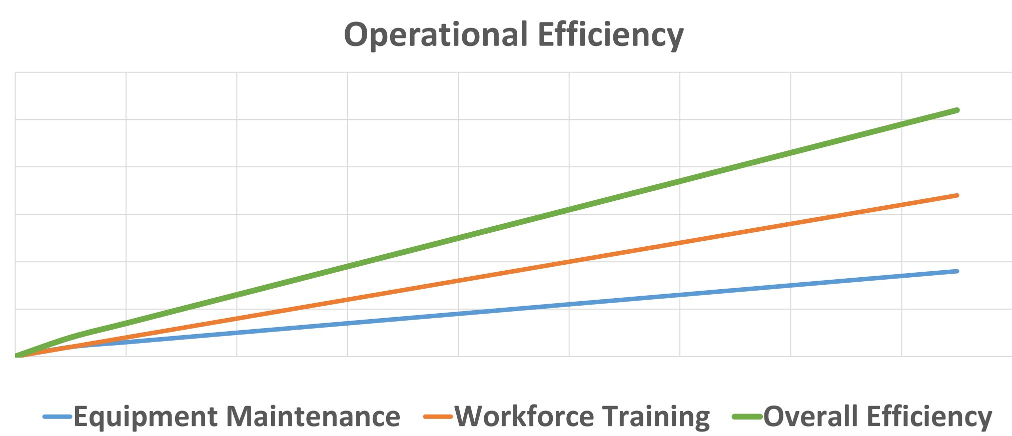


Resources and Handouts

- 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 Dehli



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)

<u>**Example Specifications:**</u>

✓**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)

<u>Example Specifications</u>:

- ✓ **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

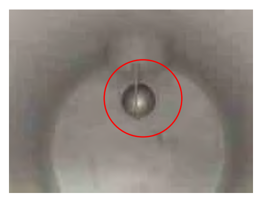
Gauges and Valves

- ✓ **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

- ✓ **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

Backhoe

✓A backhoe loader is a versatile earth-moving equipment, multipurpose machine.

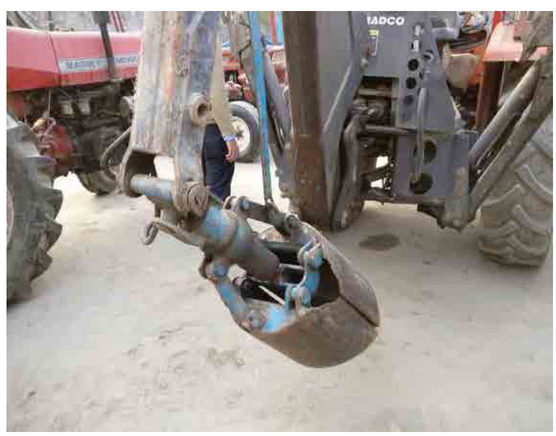
✓It can be used as an excavator and as a loader.

✓A backhoe attachment can be mounted or adjusted to allow digging along the walls.

Equipment Overview

WASA Backhoe

Koyker Backhoe with regular bucket

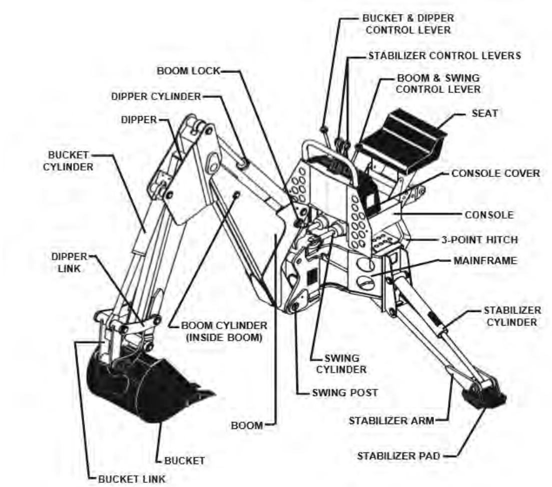


Bradco Backhoe with clamshell bucket (customised)

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

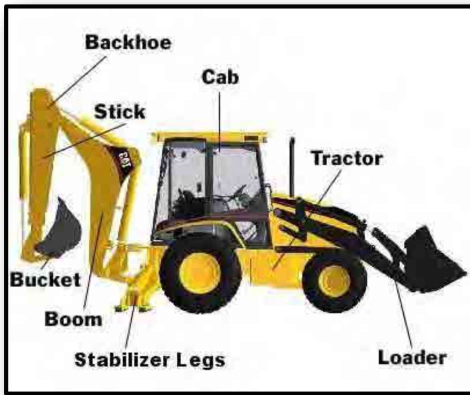
WASA Backhoe (Koyker, KB85)

- ✓**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

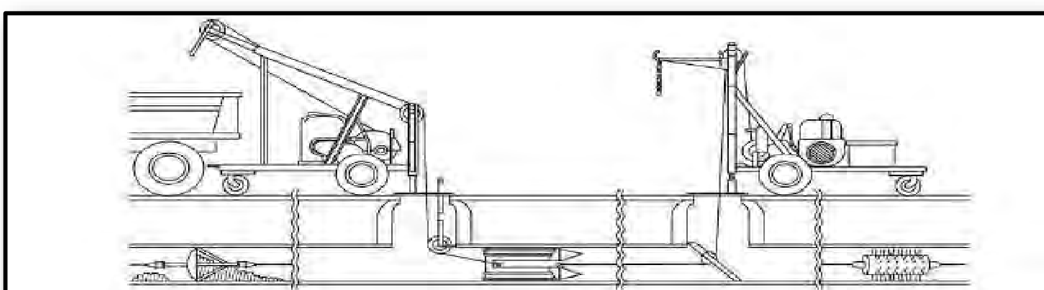
- ✓ Water is routinely transported from regions where it is plentiful to regions where it is scarce. Several water conveyance and distribution techniques are available, and are actively used in many parts of Pakistan.

- ✓ 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.

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

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

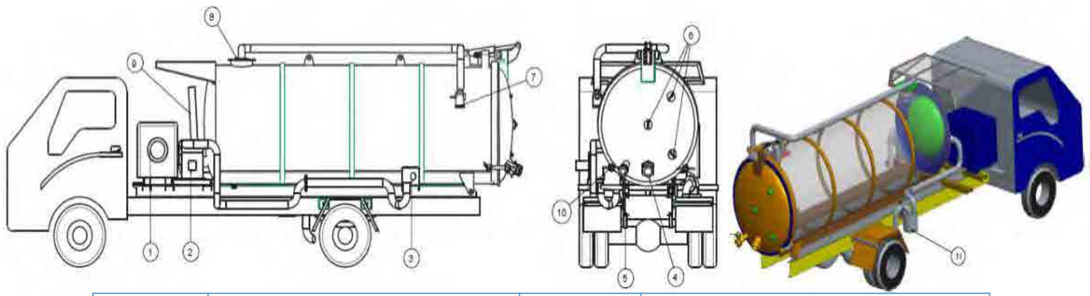
Vehicle Specification: Isuzu N-Series (courtesy RAVI Motors, Lahore)			
DIMENSION & WEIGHTS (Chassis only)		Short Wheel Base (SWB)	Long Wheel Base (LWB)
Wheel Base (WB)	mm	2460	3360
Overall Length (OAL)	mm	4610	5830
Overall Width (OW)	mm	1695	1695
Overall Height (OH)	mm	2120	2120
Tread Front (AW)	mm	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		

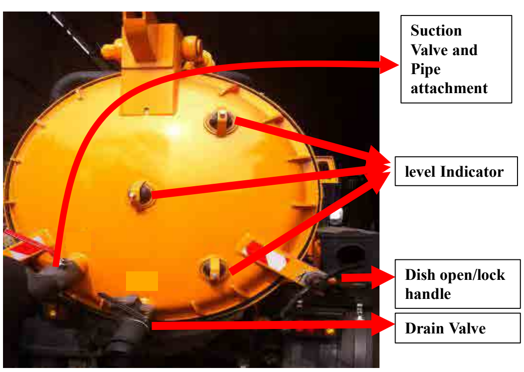
Videos for vehicle systems

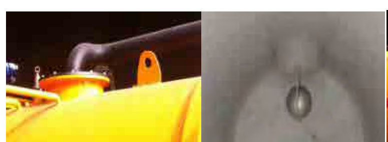
Main Assembly Component, **Suction Unit**



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**



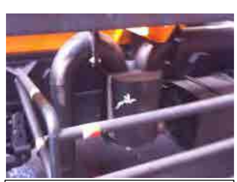

Primary CUTTOFF Protection


Secondary CUTTOFF Protection


Auxiliary Engine or Prime Mover

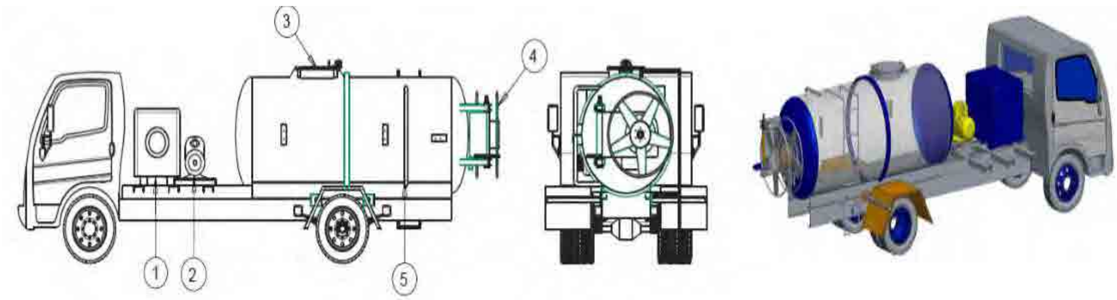

Vacuum Pump


Vacuum Pump Air intake Filter


Air outlet Silencer


Hydraulic Jack

Main Assembly Component, **Jetting Unit**



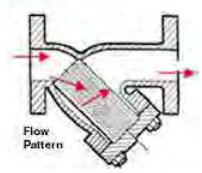
Parts No.	Description	Parts No.	Description
1	Auxiliary Engine	4	Jetting Real
2	High Pressure jetting Pump	5	Water Level Gauge
3	Manhole for water refill	6	Y Strainer

Main Assembly Component, **Jetting Unit**

Engine

High Pressure jetting Pump

Y Strainer



Manhole

Jetting Real

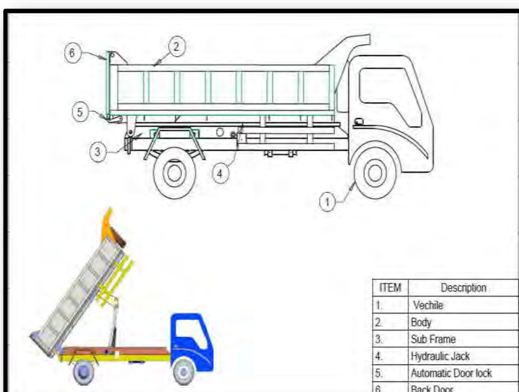
Main Assembly Component

Combined Jetting and Suction Unit

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

Main Assembly Component

Dump Truck



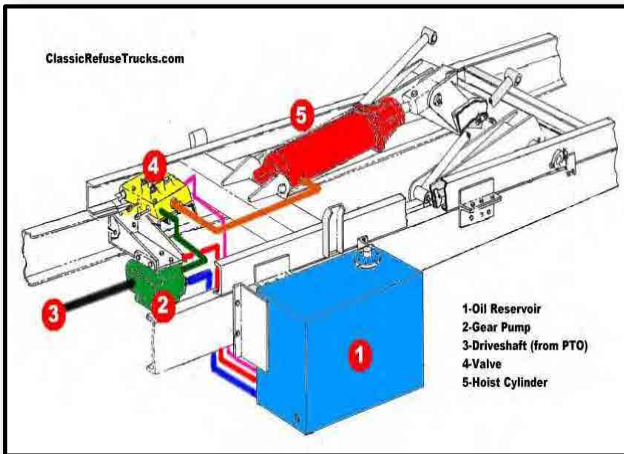
Dump Truck Components

Dump Truck (courtesy Kisaan Engineering)

Main Assembly Component

Load Capacity

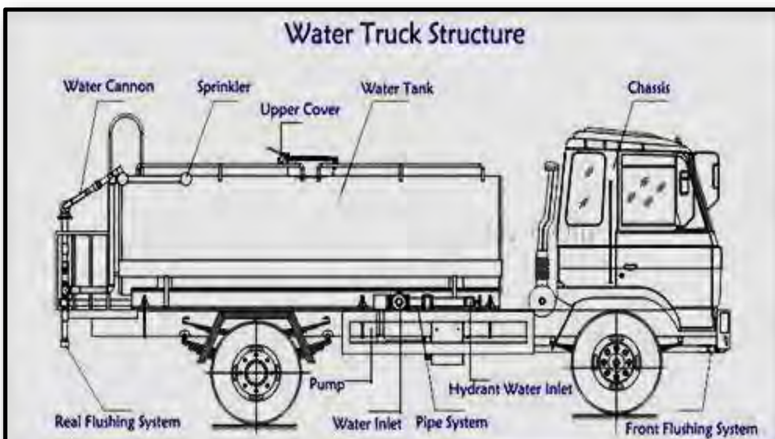
- ✓ 4 Ton or 3.3 cubic yards of dirt
- ✓ Average commercial dump truck holds anywhere from **10 to 14 cubic yards** of dirt.
- ✓ The Dump Trucks used at local service facilities are much smaller with a capacity of 5 to 10 cubic yards of dirt.



Dump Truck (courtesy Kisan Engineering)

Main Assembly Component

Water Trucks



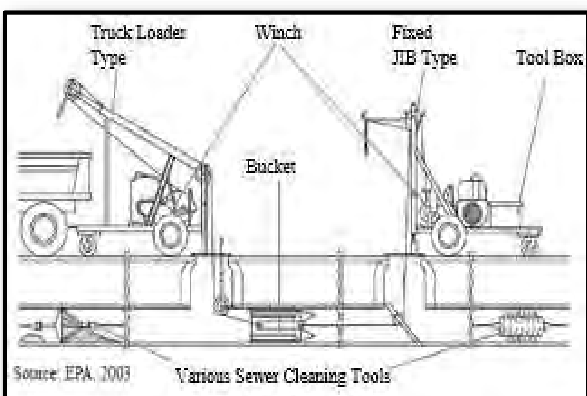
Water Tanker Components

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

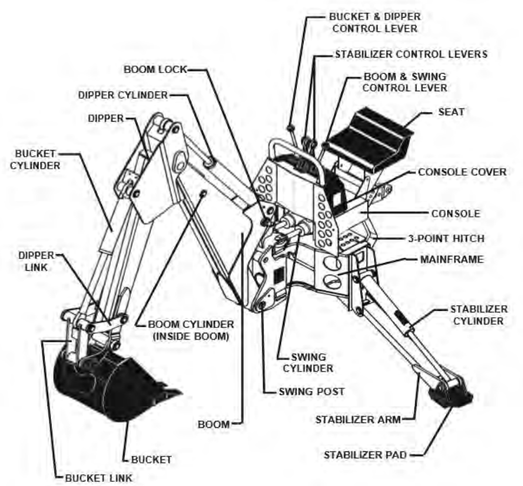
● = Most effective solution for a particular problem

• = 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

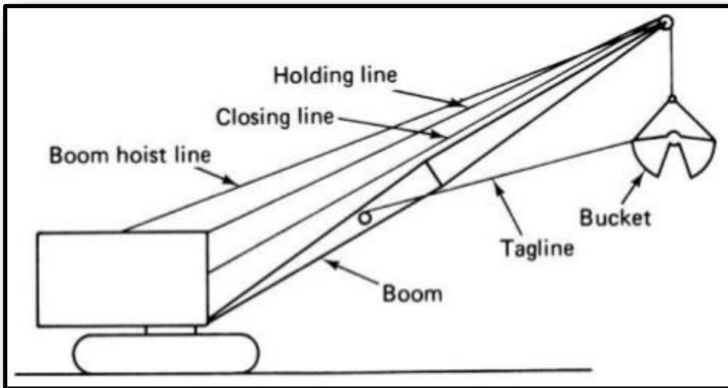
Main Assembly Component

✓**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.

Accelerator knob

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

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.

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.

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.

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

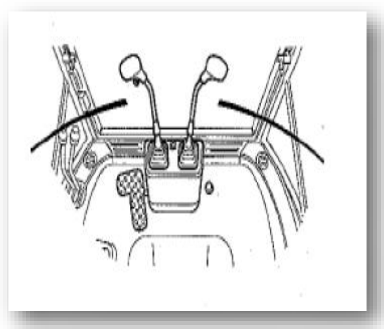
19.Levers

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

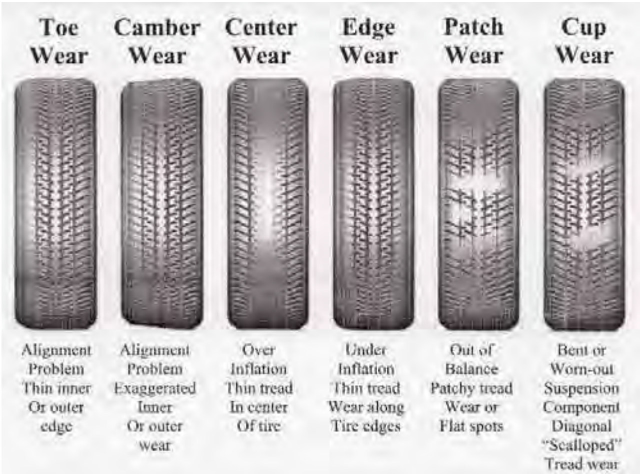
- The most important issue in your equipment's life is selecting the correct oil and changing it regularly.

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**

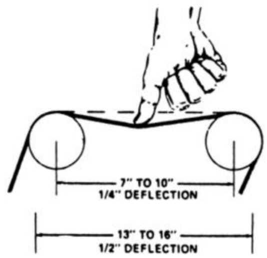
Belts drive your operations !

Worn-out belts

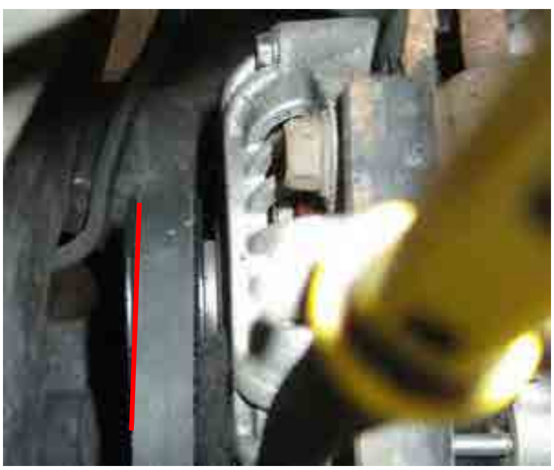
Always buy correct type!

Drive belt tension adjustment

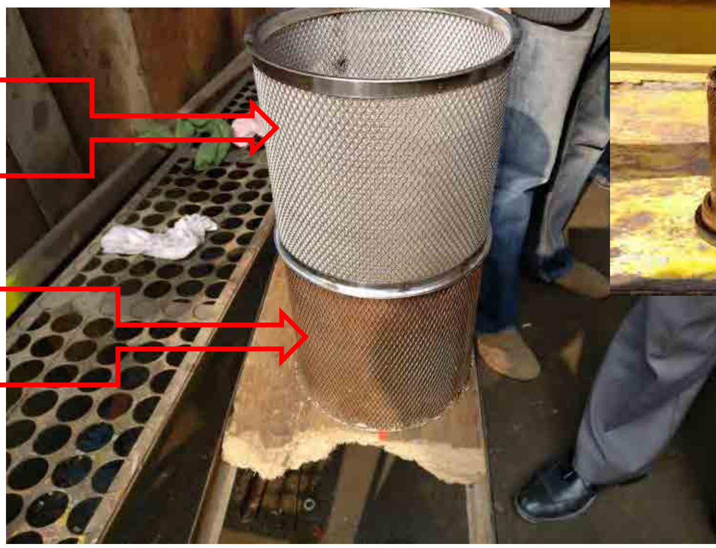
Fig. 1: A gauge is recommended, but you can check belt tension with thumb pressure



Belt alignment



Filters are lungs for your machines!



Clean Filter

Dirty Filter

Dirty Y Strainer filter

Lessons from OJT

Lessons from OJT

Lessons from OJT

Lessons from OJT

Steel Lower Manhole Guide Shoe

Lower Manhole Hose Guide Roller-Grabber

WSD 5231, Mod. 5

169

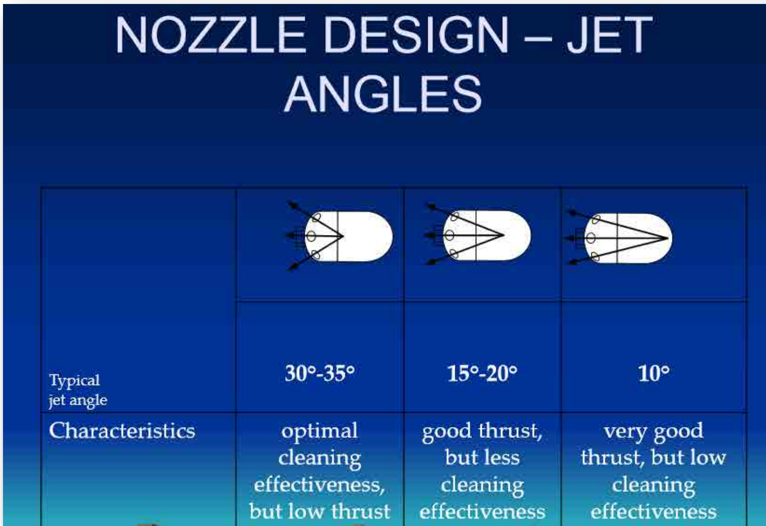
Lessons from OJT

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

WSD 5231, Mod. 5

170

Lessons from OJT



NOZZLE DESIGN – JET ANGLES

Typical jet angle	30°-35°	15°-20°	10°
Characteristics	optimal cleaning effectiveness, but low thrust	good thrust, but less cleaning effectiveness	very good thrust, but low cleaning effectiveness

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 !!!

HEAVY MACHINE OPERATOR / DRIVER RECORD

Sr.#	Name of operator / driver	License type	Issue Date	Expiry Date	Equipment / heavy machine

1

JICA

ALJAZARI ACADEMY

Health Safety & Environment for Operations and Maintenance of Pump, Induction Motor, Valves, Chlorination & Filtration System and Heavy Machines

2

Activities for On-the-Job Training

1. Pump, Induction motor & Valves
2. Chlorination & Filtration System
3. Heavy Machines
4. Water Meters

- Hazard Hunting
- Identification of applicable PPE
- Job safety analysis (JSA)
- Fire Fighting
- Electric Shock
- Electrical Safety Rules
- Safety Rules for pump, induction motor & valve
- Accident / Incident Reporting
- Guidelines to prevent incident / accident

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 induction motor or Electrical spark due to loose electrical connections.

4

Hazard Hunting

Hazard Category

- **Safety: Related to safe O&M**
- **Health: Related to protection of health of employee**
- **Environment: Related to natural / man made losses**
- **Technology: Accident / incidents related to operations etc.**
- **Behavior: Reaction of employee to working conditions**

5

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

6

Hazard Hunting

Sources of Hazard Identification

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

7

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 Control

8

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 Identification (spot)	Action needed (Assess)	Person responsible (fix)	Date of completion	Comments (Evaluate)
1.	Loose foundation bolts	Tightening of bolts	operator	13.01.17	Done
2.	Worn out Cable (induction motor)	Replacement of cable	Electrician	13.01.17	Done
3.	Oil pan leak	Replace oil pan seals	mechanic	13.01.17	Delayed

9

Current conditions of Pumps




10

Current conditions of Induction Motor

11

Current conditions of Valves

12

Current condition of chlorination & filtration system

13

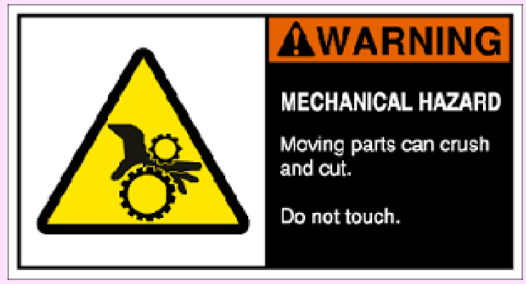
Current conditions of Heavy Machine

14
5/14

Operations & Maintenance related Hazards

Pump

1. Confined space
2. Missing warning and safety signs
3. Slip & Fall
4. Noise and vibration
5. Cut, crush, pinch
6. Corrosion and contamination
7. Defective Personal protective equipment



15

Operations & Maintenance related Hazards

Induction Motor

1. Loose electrical connections
2. Broken or damaged contacts
3. No grounding provision
4. Broken or removed casing
5. Improper wiring connection

16

Operations & Maintenance related Hazards

Induction Motor

6. Exposed electrical parts
7. Untidy cables
8. Wet & moist condition
9. Absence of safety labels
10. No housekeeping

17

Operations & Maintenance related Hazards

Valves

1. Confined space
2. Ergonomics
3. Access to operating nut
4. Slip & Fall
5. Defective hand and power tool
6. Corrosion & contamination

18

Operations & Maintenance related Hazards

Chlorination & Filtration System

1. Loose electrical connection
2. Chemical hazard
3. Slip and fall
4. Leakage or blockage
5. Bursting of pipe

19

Operations & Maintenance related Hazards

Heavy Machines

1. Physical condition of the operator or driver
2. Radiator, fan belt effects
3. Musculoskeletal injury
4. Opaque vision due to fog or mist
5. Working close to confined space
6. Working on loose soil areas
7. Release of high pressure
8. Working with heavy loads
9. Traffic hazards

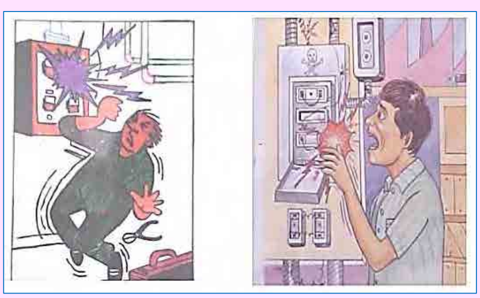
20

Operations & Maintenance related Hazards

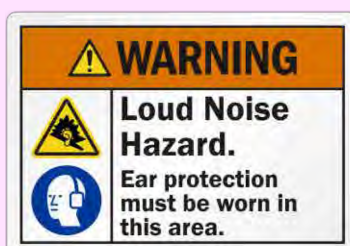
Heavy Machines

9. Heat, cold, hunger, mental stress etc.
10. Cellphone
11. Noxious emissions
12. Improper or defective PPE
13. Not using PPE
14. Carefree attitude

Major outcomes of Hazards



Electric shock



Noise & Vibration

Reddening of eye

Skin rashes

Ergonomics

Crush and Cut

Major outcomes of Hazards

Fall and Death

Fall and Death

23

Major outcomes of Hazards

Pinch, cut, strike

Accident due lack of vision or frequent movement

24

Hazard Control During Operations & Maintenance

More Effective

1	**Elimination :** Remove unsafe conditions
2	**Substitution:** Replacement of faulty or damaged parts (links, joints)
3	**Isolation:** ROPS (roll over protection)
4	**Engineering Control:** Built in structural strength
5	**Administrative Control:** Lock out / Tag out methods before maintenance work
6	**PPE:** Use PPE, i.e. safety glasses, gloves, shoes with toe protection, hard hat, reflective jacket

Less Effective

25

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**

26

Applicable Personal Protective Equipment

1. **Helmet with chin brace**
2. **Safety goggles**
3. **Ear plugs**
4. **Gloves**
5. **Rubber gloves**
6. **Safety vest**
7. **Safety shoes**
8. **Face mask**








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

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.

29

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

30

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

31

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

32

Job Safety Analysis (JSA) Example - 01

Location:	**HEAVY MACHINE STOCK YARD**
Date:	**December 20th, 2016**
Conducted By:	**SDO and Operations Staff**

Sr. No.	Hazards Identified	Hazards Type	Probability Ratings	Severity Ratings	Priority Rating	Action Needed	Assigned to	Due Date/ Time	Date Completed	Comments
1	Open Ditch in zone 2	Fall and Roll	5	5	25(H)	Fill and compact	Electrician & operator	31st Oct 16	30th Oct 16	Done
2	Seat belts worn out on Backhoe 2	Injury (head and torso)	3	4	12 (H)	Replace seat belts	Electrician & operator	1st Nov 16	Done	Seat belts ordered
3	Oil pan leaking on Water Truck 5	Slip and Environment	2	3	6 (M)	Repair oil pan seal	Electrician & operator	14th Nov 16	Done	Parts ordered

Priority ratings is obtained from multiplication of the Probability and Severity ratings
(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.

33

Job Safety Analysis (JSA) Example - 02

Location	**Heavy Machine Stock Yard,**
Date	**December 5th, 2016**
Conducted By	**SDO and Operations Staff Main Outfall**

Sr. No.	Hazards Identified	Hazards Type	Probability Ratings	Severity Ratings	Priority Rating	Action Needed	Assigned to:	Due Date/Time	Date Completed	Comments
1	Live electrical wires not insulated in stock yard	Electrical Shock	5	5	25(H)	Insulate wires	Electrician & operator	31st Oct 16		delayed
2	Oil spill in work zone 9	Slip and Environment	4	5	20(H)	Remove oil spill and reclaim soil	Electrician & operator	1st Nov 16		
3	Tools left on workshop floor	Trip and Fall	2	3	6(M)	Repair chair	Electrician & operator	14th Nov 16		
4	Chair leg broken at cubical 2	Fall	2	3	6(M)	Repair chair	Electrician & operator	14th Nov 16		

Priority rating is obtained from <u>multiplication</u> of the Probability and Severity ratings (Hazard = Probability x Severity)

1) **<u>Governing Range: 1 - 25, (1 being the Lowest, 25 is highest priority).</u>**
2) **Hazard Hunting must be performed on routine bases**

34

Fire Fighting

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

35

Fire Fighting

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

36

Always remember

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

37

Steps of using fire Extinguisher

38

Valve Safety Rules

Operation & Maintenance of valve can result in injury or valve damage. Incorrect application of valve includes but is not limited to:

- Exceeding the pressure rating
- Failing to maintain valve according to the recommendations of manufacturer
- Proper containment of valve is required.
- Do not remove the contact guard for moving parts when valve is in operation. Never operate valve without the contact guard installed.
- Do not use valve as a step or hand hold.
- Do not paint over the identification tag, warnings, notices, or other identification marks associated with valve.
- Decontaminate the valve exposed to harmful substances such as caustic chemicals, wastewater.
- Lock-out to isolate the valve from all power sources before performing maintenance on externally actuated valves.

39

Chemical handling and storage safety guidelines of chlorine

Storage Safety

- Store chlorine container in an area that is cool, dry, and well-ventilated.
- Keep chlorine out of direct sunlight and away from heat and ignition sources.
- Secure and separate from filtration area, separate from incompatible materials.
- Always secure container in an upright position to a wall, rack or other solid structure.
- Label container with date received, date opened and disposal date.
- Use a first-in, first-out inventory system.
- Empty containers may contain hazardous residue. Store separately.

40

First Aid Guidelines

Provision of first aid kit & formation first aid team at Chlorination and filtration system is essential.

In case of minor problem first aid kit may be helpful.

For major accident rescue 1122 may be called.

WASA facility in charge should constitute a first aid team for operation and maintenance accidents or incidents.

First Aid Team

The first aid team should comprise of trained:

- First Aider
- A rescuer
- A helper

41

First aid measures for chlorine

Inhalation: Wear Safety mask before rescue.

Move victim to fresh air. Keeping chin upward

Keep victim in a position comfortable for breathing

If breathing is difficult, buddy should administer oxygen by putting some neat cloth on the mouth of victim. Pinch the nose of victim before breathing

DO NOT allow victim to move about unnecessarily.

Immediately call RESCUE 1122 & shift to hospital.

42

First aid measures for chlorine

Skin Contact: Flush with lukewarm water gently for 5 minutes.

If irritation or pain persists, see a doctor.

Quickly remove victim from source of contamination.

DO NOT attempt to rewarm the affected area on site.

DO NOT rub area or apply direct heat.

Gently remove clothing or jewelry that may restrict circulation.

Carefully remove the rest of the garment.

Loosely cover the affected area with a sterile dressing.

DO NOT allow victim to drink alcohol or smoke.

Immediately call RESCUE 1122 & Shift to hospital.

43

First aid measures for chlorine

Eye Contact:

Immediately flush the contaminated eye(s) with lukewarm gently flowing water for 5 minutes, while holding the eyelid(s) open.

If irritation or pain persists, see a doctor.

Avoid direct contact . Wear chemical protective gloves

Immediately and briefly flush with lukewarm, gently flowing water.

DO NOT attempt to rewarm.

Cover both eyes with a sterile dressing.

DO NOT allow victim to drink alcohol or smoke. Immediately call RESCUE 1122 & shift to hospital

44

First Aid Box

Accessories

- Panadol or Paracetamol
- Dichloron
- Sterile gauze pads of different sizes
- Adhesive tape
- Adhesive bandages of several sizes
- Elastic bandage
- Splints
- Antiseptic wipes
- Antibiotic ointment
- Antiseptic solution
- Tweezers
- Sharp scissors
- Safety pins
- Thermometer
- Antihistamine tablets
- Distilled water for cleaning wounds or burns
- Eye wash

45

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..

46

Accident or Incident Report Template

VICTIM—*Name*	Mr. Aslam Malik					Phone No	0300-4546145
Address	26 New Muslim Town, Lahore						
Occupation	Electrician		Injuries received	Burn			

INCIDENT SITE—*Occupiers name*	Chlorination and filtration plant							
Address	Allama Iqbal Town, Lahore							
Incident date	14/10/2016	Phone No	042-35760573	Fax No	35767173	WASA property Yes ☑ No ☐		
Reported to supervisor by	Engr. Ghulam Farid			Date	14/10/16	Time	4:00pm	

INCIDENT DETAILS Location—e.g. Tube-well station	Tube Well Station, Allama Iqbal Town, Lahore
What was contacted for the shock current to enter and leave the victim—e.g. Wire or cable or source of injury	Defunct chlorinator
Please describe how the incident happened?	
Electrician was repairing chlorinator without using any PPE. Forceful opening of jammed casing Sodium hypochlorite solution fell in eyes.	

EQUIPMENT INVOLVED

Article	Trade name	Model	Approval No.	Insulation Ω	Earth Ω
Chlorinator pump	WASCO	1999	IS799		

47

solution fell in eyes.

EQUIPMENT INVOLVED					
Article	Trade name	Model	Approval No.	Insulation Ω	Earth Ω
Chlorinator pump	WASCO	1999	IS799		

Property damage details: Chlorinator pump fell and casing broke

INVESTIGATION	
Cause of incident identified as	Carefree attitude of Electrician. Not using any PPE such as gloves, facemask and Goggles during operation and maintenance.
Action taken to make safe	Installation of sodium hypochlorite MSDS. Provision of PPE for example helmet, Safety mask, safety goggles at chlorination and filtration plant
Job referred to—e.g. Repair and maintenance	WASA repair and maintenance shop

Witness 1		**Witness 2**	
Name	Mehboob Ul Hassan	Name	Athar Ali
Designation	Helper	Designation	Sanitary worker
Cell No	0300-9596854	Cell No	0321-4252662

INVESTIGATORS:

Electrical Workers	Engr. Suman Khalid	Phone No	0321-4040124	Fax No	Nil		
Employer	WASA						
Address	Zahoor Elahi Road, Gulberg Lahore						
Date/s of investigation	14/10/16	Person compiling report	Mr. Muhammad Ali				
Signature		Title	Sub Engineer, Allama Iqbal Town	Date			

48

Guidelines to prevent incident/accident for heavy machines

1) Pre-start/Walk around Inspection

- 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.
- Inspect hydraulic line connectors and hose 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.
- A fire extinguisher and first aid kit may be mounted in the cab of some equipment.
- Ensure the cab area is clean and free of debris and tools.
- Clean windshield, mirrors and lights.
- Removal all oil, grease or mud and snow from grab irons, hand rails, steps, pedals and floor to prevent slips and falls.
- Remove or secure any loose items such as tools, chains or lunch boxes from the cab

49

Guidelines to prevent incident/accident for heavy machines

2) Work Site

- Check and mark the area for underground cables, gas lines and water mains.
- Know work area clearances- watch for overhead or underground objects, holes, drop offs, and partially hidden obstacles and wires.
- Barricade the work areas, if needed

50

Guidelines to prevent incident/accident for heavy machines

3) Mount Properly

- Do not get on or off a machine that is in motion!
- Maintain a 3-point contact with the steps and hand rails while getting on/into the machine- do not use the controls or steering wheel as a handhold.
- Do not operate the machine with wet, greasy or muddy hands or shoes.
- Always wear a seat belt while driving

Proper Mounting with three point contact and wear a seat belt

51

Guidelines to prevent incident/accident for heavy machines

4) Refueling

- Shut off and cool the engine and any electrical equipment before fueling.
- Ensure the fueling area is well ventilated.
- Do not smoke while refueling. Keep open flames and sparks away from area.
- Do not use gasoline or diesel fuel for cleaning parts.
- Know where the fire extinguishers are located.

5) Shut Down/Parking

- Park on level ground.
- When parking on a grade, 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.

52

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

Causes of Accidents

- Slips and falls while mounting and dismounting from the Backhoe/Front End Loader are the most common accidents for operator
- Electrocution may result from contacting power lines
- Never approach power lines with any part of machine
- Keep away from machine that has come in contact with a power source
- Always know overhead clearances before starting the job

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

- When disconnecting battery cables, disconnect the negative (-) cable first
- When connecting battery cables, always connect the negative (-) last
- Always avoid traveling across a slope
- Better to travel up slope in forward and down slope in reverse, when carrying a load
- If operating on a slope, always dump the spoil on the uphill side of the trench – extending the loaded backhoe bucket downhill increases the risk of tipping the backhoe loader

54

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

How to avoid a roll away machine:

- Park the machine on level ground and engage parking brake
- Place transmission control in neutral "N"; engage neutral lock (if equipped)
- Lower all attachments to the ground and ensure that the locks are in place
- Stop the engine
- Block all wheels if parking on a grade
- Position machine to prevent rolling
- Park a reasonable distance from other machines

55

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

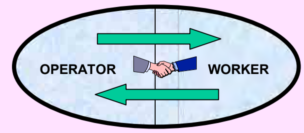
For Safe Operation of heavy machine

- Never Take Anything For Granted
- Face the Machine When Climbing on and off
- Keep The Machine Clean
- Clean Mud And Grease From Shoes
- Avoid Loose Clothing And Jewelry
- Wear Protective Equipment
- Never Operate Machine Without Protective Guards
- Always Check Height, Width, and Weight Restrictions
- Keep all Safety Devices in Place and Working Order
- Plan Ahead
- Learn Beforehand About the Work Area

56

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

Job Site Safety



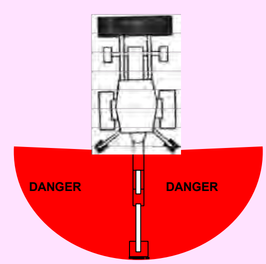
Job site safety is every one's responsibility

- **Performing operations with a loader/backhoe, operator of the machine and those assisting him on the ground need to work as a team**
- **Those on the ground should notify if anything out of order**
- **Operator should take care of ground workers if come within range of the machine**

57

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

Danger Area



When the backhoe of a loader/backhoe is in operation

- **No one should enter the full swing area**
- **Operator's vision of this area is not always clear and may cause mishap**

58

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

Always keep eye contact during operations

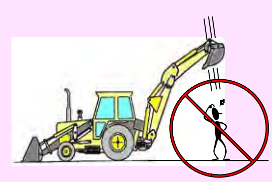
- If worker enters swing area, he must establish eye contact with the operator
- The worker must wait until the operator signals him that it is safe
- Operator should not move the backhoe until the worker has cleared the area

59

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

Always work facing the machine

- Working around a loader/backhoe, the worker should always work facing the machine
- He should consider the machine a threat to his safety and must be vigilant about its movement



60

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

ALJAZARI ACADEMY

Excavating Hazards

Before commencement of excavation, the location and type of all buried hazards needs to be determined

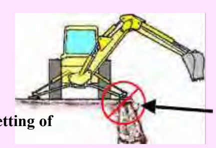
- **Utility companies should be contacted for the location of their buried service lines**
- **It is necessary to contact agencies like TEPA , LDA , LESCO to identified buried services**
- **When the excavation approaches a buried object, manual excavation should be done**

61

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

ALJAZARI ACADEMY

Excavating Hazards



- **The stabilizers of a backhoe need to be set far enough from the edge of a trench to avoid a cave-in**
- **Avoid placing the stabilizers closer than two feet from the edge**
- **When the backhoe is swung to the side, the ground pressure from the stabilizer pad increases**
- **The amount of pressure depends on the weight being swung**

The Rule of Thumb for setup of heavy machine on unstable soils is:

The distance the stabilizer is from the trench edge is equal to the depth of the trench

62

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

Jetting Machine

- Suction pump consumes oil and should never run dry
- Always use ignition switch to start
- Don't lit fire near engine
- Switch off engine during fueling
- Don't remove lid of radiator or tank when engine is start
- Don't mix petrol, kerosene oil
- Don't clean air cleaner with petrol
- For repair and maintenance consult certified workshop

63

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

Tractor

- Don't start tractor while standing beside it
- Always start while sitting on the seat with prior check of gear lever, PTO neutral and starting switch pressed inside
- Always use footrest for climbing
- Don't press parking brakes and never get down while tractor is moving
- Keep tractor in gear for parking uphill
- Lock both brake paddles while traveling on road
- Don't use differential lock while taking turn
- Don't pull any load at the center line of the axle
- Keep PTO neutral before attaching / detaching any component
- Keep attachments down if tractor is not working

64

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

Tractor

- Never remove thermostat valve from engine
- Never keep tractor close to fire
- Always remove battery clips before welding or repair & maintenance task
- Don't lit fire near engine
- Switch off engine during fueling
- Don't remove lid of radiator or tank when engine is start
- Don't mix petrol, kerosene oil
- Don't clean air cleaner with petrol
- For repair and maintenance consult certified workshop

65

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

Water Tanker

- 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
- Allow sufficient time to warm the truck up (operating a "cold" truck can impact the vacuum braking system)
- Always wear seat belt
- Stay attentive - Watch for possible hazards (equipment and workers)
- Adjust mirrors before trip and use them often to monitor the activity around you
- Confirm that regular maintenance is performed, making sure braking systems are maintained according to manufacturer specifications

66

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

Water Tanker

- **Operate water trucks on safe haul roads (areas designed for vehicles)**
- **Drive Smoothly - Because of the high center of gravity, and the surge of the liquid, you must start, slow, and stop, very smoothly. Make smooth turns and lane changes.**
- **If you must make a quick stop, use controlled or stab braking. Remember - If you steer quickly while braking, your vehicle may roll over.**
- **If you lose brake pressure during, pull the emergency brake and use the manual transmission to stop the truck**

67

SAFETY GUIDELINES FOR OPERATOR / DRIVERS

Water Tanker

Pre-inspection safety check

- Important item is to check for any leak
- Check under and around the vehicle for signs of any leaking
- Avoid carrying liquids or gases in a leaking tank

Safety Checks

- The tank’s body or shell for dents or leaks
- The intake, discharge, and cutoff valves - Make sure the valves are in the closed position except when loading or unloading
- The pipes, connections, and hoses for leaks, especially around joints
- The manhole covers and vents
- Drive slowly and be careful in taking curves or making sharp turns with a partially or fully loaded tanker
- Be extremely cautious (slow and careful) when driving smooth bore tanks, especially when starting and stopping

68

Safe Procedure to use Self Contained Breathing Apparatus & Winch Machine

Breathing Apparatus

A device that provides breathable air in an atmosphere that poses immediate danger to life and health (IDLH).

BA	**Breathing Apparatus**
CABA	**Compressed Air Breathing Apparatus**
SCBA	**Self Contained Breathing Apparatus**
SCUBA	**Self Contained Underwater Breathing Apparatus**

BREATHING UNDER VARYING DEGREES OF EXERTION

Degrees of exertion	Number of respirations	Air breathed (lpm)	Oxygen consumed (lpm)
Rest in bed	16.8	7.7	0.237
Rest standing	17.1	10.4	0.328
Walking at 3.2 kmph	14.7	18.6	0.780
Waling at 4.8 kmph	16.2	24.8	1.065
Walking at 6.4 kmph	18.2	37.3	1.595
Walking at 8 Kmph	19.5	60.9	2. 43

RESPIRATORY HAZARDS

a) Elevated temperature

b) Flash over

c) Oxygen deficiency

d) Toxic gases

e) Smoke, suspended particles, fibres

OXYGEN DEFICIENCY

% OXYGEN IN AIR	SYMPTOMS
21%	NONE, NORMAL CONDITION
17%	SOME IMPAIRMENT OF MUSCULAR COORDINATION; INCREASE IN RESPIRATORY RATE TO COMPENSATE FOR LOWER OXYGEN CONTENT
12%	DIZZINESS; HEADACHE; RAPID FATIGUE
9%	UNCONSCIOUSNESS
6%	DEATH WITHIN A FEW MINUTES FROM RESPIRATORY FAILURE AND CONCURRENT HEART FAILURE

5

OXYGEN DEFICIENCY……

TIME IS CRITICAL

6

TOXIC GASES

- Exposure to irritants and toxicants. (TLV)
- Combined effect of two or more substances is more toxic: somewhat like 1+1=3.

Toxic gases,

- E.g: – Carbon monoxide, Hydrogen cyanide, Hydrogen sulphide, Nitrogen oxides, Sulphur oxides… etc..

Advantages of SCABA

- Simple in assembling and operation
- Less training required
- Cylinders can be easily charged and changed quickly
- Air remains cool as no chemical action involved
- Communication by word of mouth (instead of line signals)

Requirements of Wearer

- The wearer must have good Health, good physique and Medically fit
- He must have body agility and clear Facial features

9

PARTS OF SCBA

- Cylinder
- Cylinder valve
- Back plate
- Harness assembly
- High pressure hose
- Low pressure hose
- Pressure gauge
- Pressure reducer
- Warning whistle
- Face piece

10

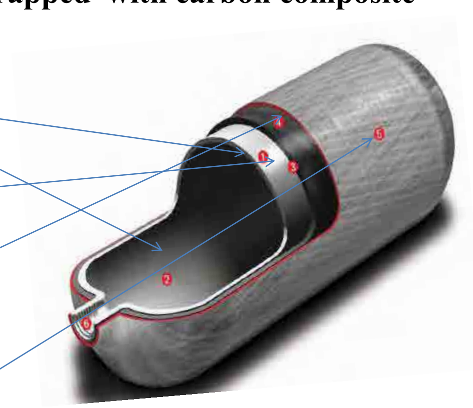
FACE PIECE & LDV

Head & neck harness
Visor
Face seal
Ori-nasal inner mask
Inhalation valve
Exhalation valve
Speech diaphragm
LDV

CYLINDER

Construction
Aluminium cylinder Fully wrapped with carbon composite

1. **Aluminium liner**
2. **Corrosion resistant internal finish**
3. **Insulating layer liner and overwrap.**
4. **Carbon fibre overwrap in epoxy resin matrix**
5. **FRP protective layer with smooth gel coat**

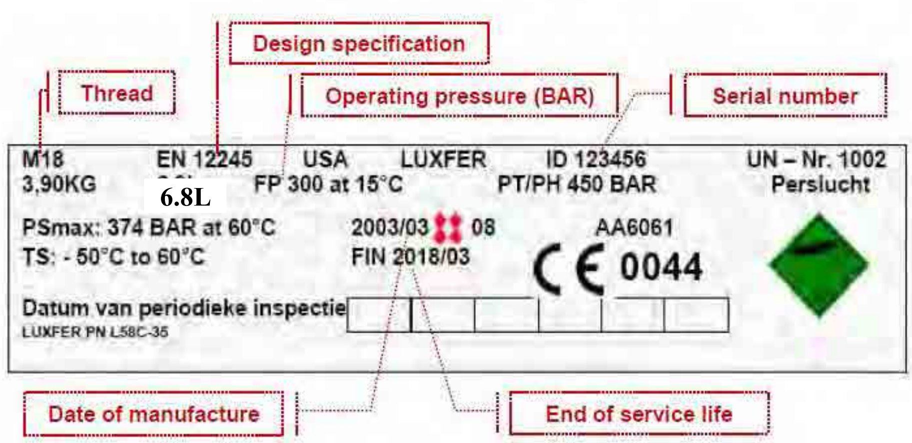


CYLINDER DETAILS

- Water Capacity 6.8 litres
- Weight 4.2 kg
- Pressure 300 bar
- Capacity 1840 litres free air
- Full Duration 46 minutes
- Working Duration 36 minutes
- Safety Margin 10 minutes.
- Life: 15 – 30 Years

13

LABEL ON CYLINDER



14

CYLINDER VALVE & PRESSURE REDUCER

- Valve - protected by rubber buffer
- Hand wheel - fitted with a ratchet
- Cylinder pressure - converted in 2 stages.
- The first stage reducer - 300 bar to approx 7.5 bar
- Second stage reducer (LDV) - 7.5 Bar to Slightly above Normal Atm. Pressure.
- Safety Valve

PRESSURE GAUGE HOSE

The High pressure hose is tested with:

- Test pressure 450 bar &
- Burst pressure of 800 bar.

The flow restrictor in the reducer (first stage) will restrict the flow to approx 8-9 lpm at 70 bar if any defect occur in the hose.

LUNG DEMAND VALVE (LDV)

- Fitted on Low Pressure Hose
- Regulates the flow of air into the facemask.
- Satisfies the operator's requirement for air.
- Sustains positive pressure
- Screw-in connector with swivel feature
- Detachable
- Quick release male coupling
- Supplementary air supply facility
- Manually operated reset button

17

LUNG DEMAND VALVE (LDV) (contd..)

First breath mechanism	Additional air switch
• Started by lowering the pressure within the facemask, on inhalation by the operator. • This allows the set to be switched on without the facemask having to be held onto the face.	• Located at the centre of the protective rubber cover at the front of the LDV. • continuous flow of air (nominal 150 lpm) to the mask.

18

PRESSURE GAUGE & WHISTLE

Pressure Gauge	Whistle
• Constant indication of pressure. • Stainless steel casing. • Rubber cover • Calibrated from zero to 350 bar in 10 bar calibrations. • Luminous back plate	• When pressure drops to 20% of the fully charged cylinder capacity (50-60 bar). • consumption - 2 litres of air per minute.

19

FACE MASK

- Moulded rubber piece
- Reflex seal
- Adjustable head harness made of neoprene
- Full vision visor made of acrylic with 180˚vision
- Inner nasal mask
- Front port assembly with exhalation valve and plug-in port connection

20

DURATION OF AIR SUPPLY

- Physical condition of the user
- Degree of physical exertion
- Emotional stability of the user
- Condition of the apparatus
- Cylinder pressure before use
- Amount training and experience with BA

DURATION (TERMS)

- FULL DURATION : Total volume /40
- SAFETY MARGIN (NORMALLY 10 MIN)
- WORKING DURATION: FD – SM

CALCULATION OF WORKING DURATION

Working duration = Volume/Consumption rate-10

(Safety Margin is 10 Minutes)

WD = (V/40) - 10

@300Bar, 1840L ÷ 40) – 10 = **36 min**

@ 200 bar, = (200/300 × 1840) ÷ 40) –10 = **21**min

23

POINTS TO REMEMBER WHILE USING Breathing Apparatus

- **Be in good physical condition**
- **Check face piece for leaks**
- **Make sure the set is operating properly before entering hazardous atmosphere**
- **Work in pairs and stay in oral or visual contact with each other**
- **Work efficiently to conserve air**
- **Do not take off face piece if out of breathing air**
- **Do not take off face piece as soon as the fire is knocked down**
- **Take breath and long pause when air is limited in the cylinder when working**

24

SAFETY PRECAUTIONS

a) Keep hygiene of the face mask.

b) Clean the facemask after every use/change of wearers.

c) Do not connect facemask while wearing which may cause damage

d) Keep face mask safe from chemicals, dusts, insects..etc

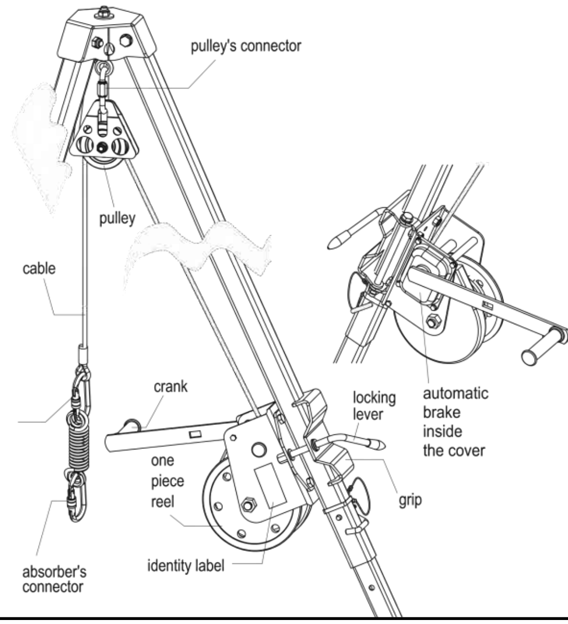
e) When entering a hazardous area the pressure should be noted down by the concerned supervisor.

f) Do not keep the cylinder where the heat of fire can directly affect the cylinder.

AFTER USE

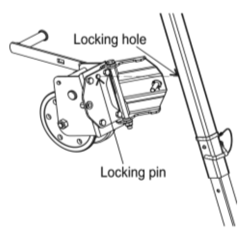
- Do not remove or switch off the unit until safe area of hazards
- Disconnect the unit from the harness strap
- Carry out a functional test
- Clean the unit if necessary
- Store the unit in accordance with the storage instructions

Labelled Diagram of Tripod Stand

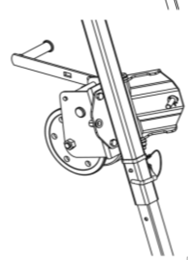


Installation Procedure of Tripod Stand

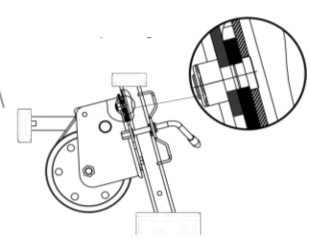
1. Opening of grip



2. Putting the tripod legs and lock

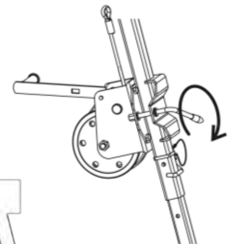


3. Fitting the locking pin in the hole

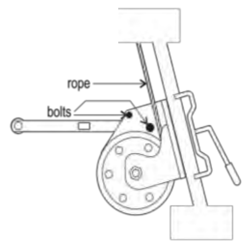


Installation Procedure of Tripod Stand

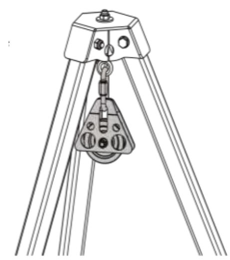
4. Closing the grip lock and greasing the lever



5. Guiding the rope behind the bolts



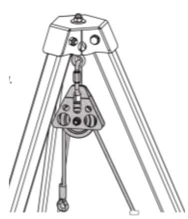
6. Anchoring the pulley



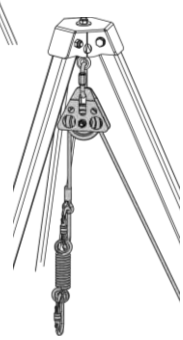
29

Installation Procedure of Tripod Stand

7. Putting the rope on the pulley



8. Attaching the energy absorber



9. Connecting absorber's connector to the attachment

30

Tripod with Hand Winch& Multi body Rescue Harness

- The top diameter of manhole is 22-24 inch.
- Rope is used for descent and ascent of worker in manhole.
- The method used not only injures them but makes it difficult during emergency ascents
- Tripod is used along with Hand Winch & Multi body rescue harness for descent and ascent of worker in
- manhole
- It is easy to operate the winch with small force.
- The sewer man does not lose his balance and can easily be withdrawn from the manhole

31

O & M of Mechanical and Electrical Equipment
WSD 5231

Water Meter Introduction and Selection

Module 7

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.

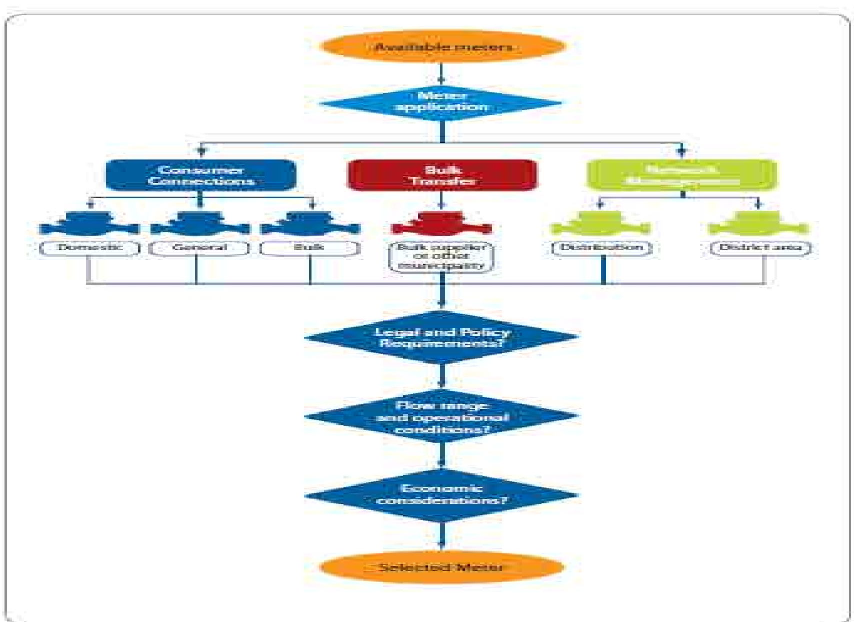
Importance of water meters

- ✓ 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

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

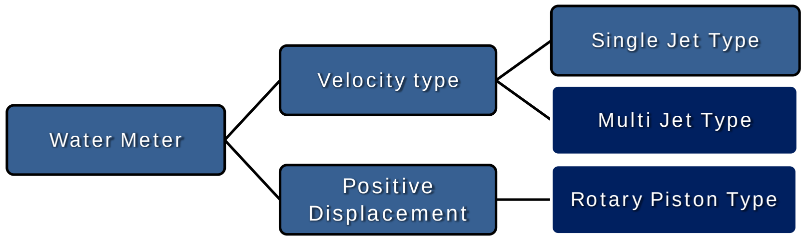
- ✓ Purpose
- ✓ There are three major applications of water meters:

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 Type in WASA (Consumer Meters)



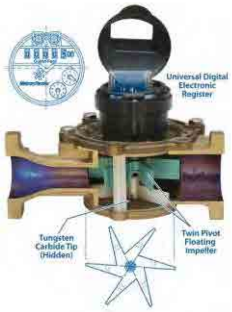
Dry type & Wet type

- 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.



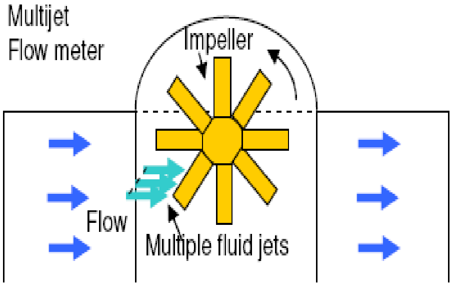
Multi Jet Type

- 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.

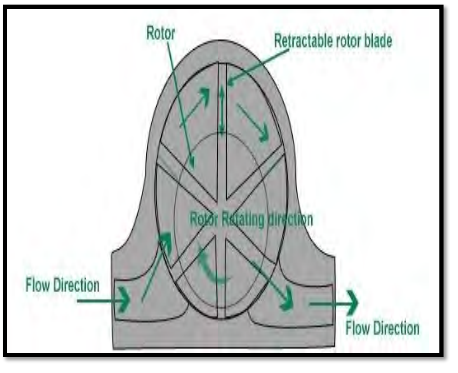
Multi-jet meters

✓ 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.

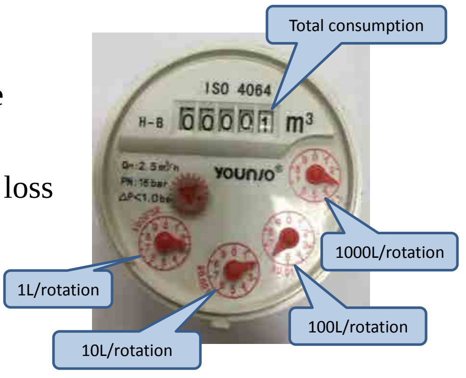


Oscillating piston meter

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:**

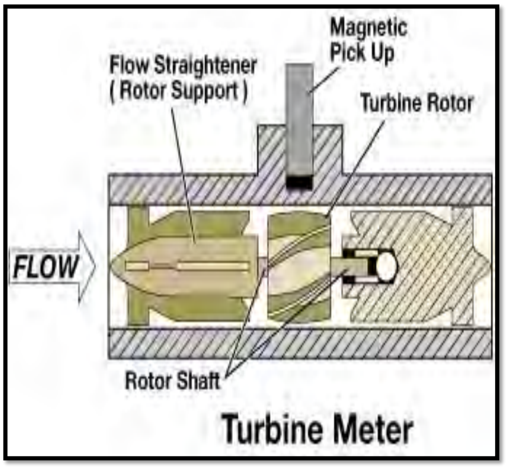
e.g.: The water meter shall conform to the pressure resistance performance.

Comparison of water meters

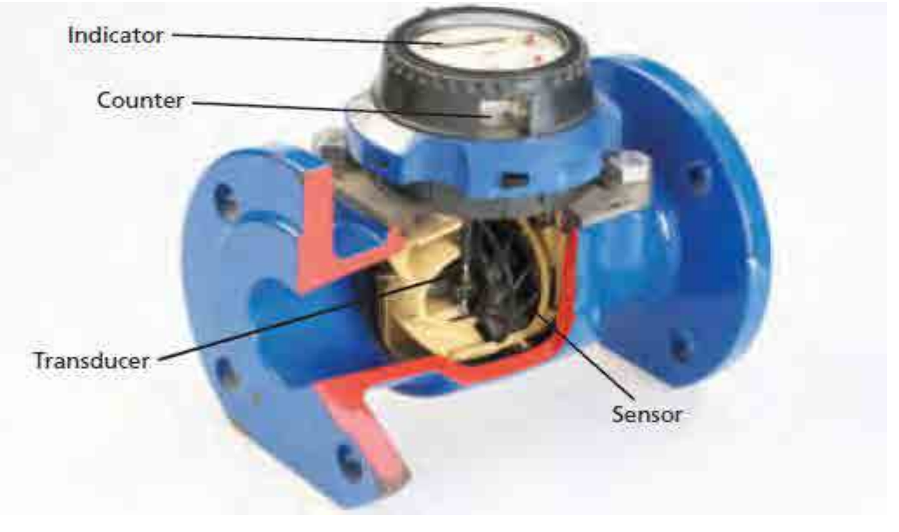
	Single jet (dry)	Multi jet (wet)	Rotary piston (wet)
Appearance			
Measuring method	Velocity	Velocity	Positive displacement
Structure	Simple structure	Complicated than Single jet	Complicated than others
Cost	Inexpensive	Inexpensive	More expensive than others
Others	Highly reliable operation	Small amount 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.

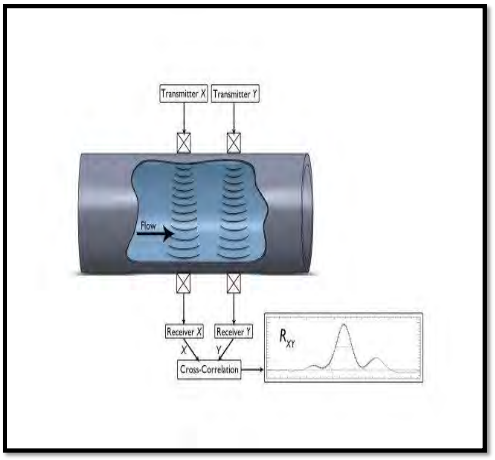


Section through a flow meter showing the sensor, transducer, counter and indicator (meter supplied by Sensus)



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.



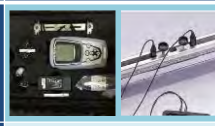
Ultrasonic meter

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

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

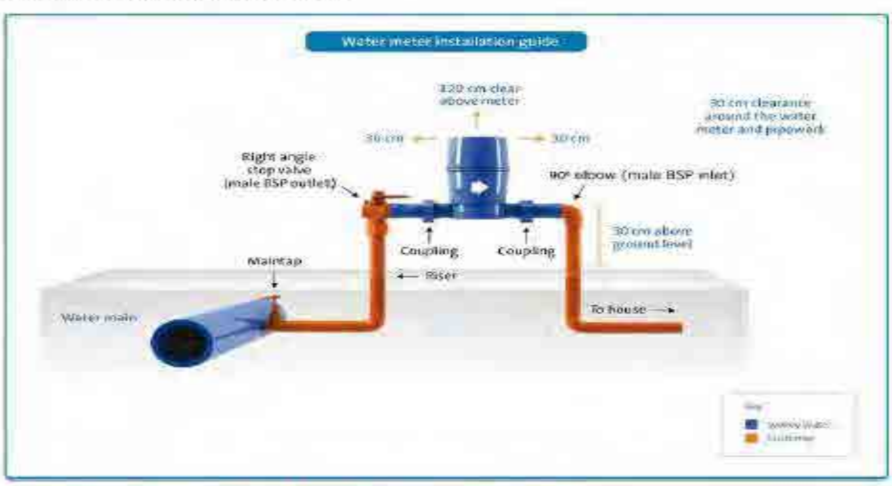
iv. and outlet riser are parallel to the closest side boundary

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

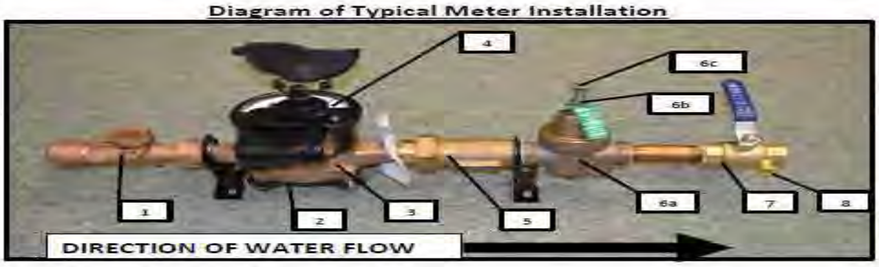
20 mm to 50 mm light duty meters



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