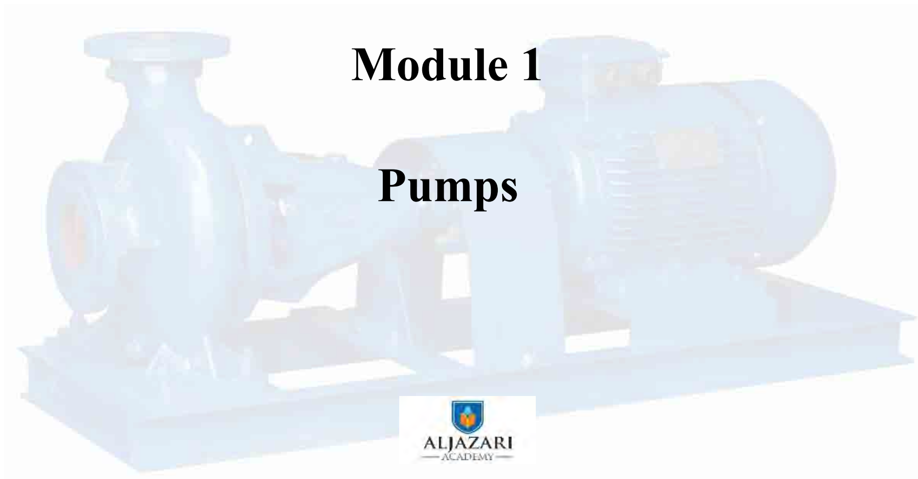
Annex 4.31
Training Material for O&M of Mechanical Equipment
in Spring 2018

O & M of Mechanical Equipment

Faculty Names	Contact Information
JICA Expert Ryuta Kudo (Mechanical)	
Course Leader Mubasher Ahmad Cheema	
Sr. Instructor Jawad Shahid	
Sr. Instructor Ihsan-ul-haque Javed	
Young Professional Tanveer Shahzad	

O & M of Mechanical Equipment
WSD 5231



Module 1

Pumps

Topics to cover..

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

Topics to cover..

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

Icebreaker and Class Introduction

Now it is your turn…

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

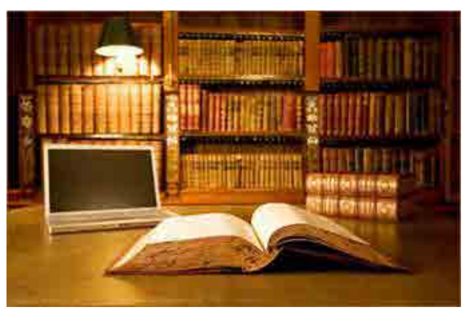
Brainstorming

Now it is your turn…

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

Resources and Handouts

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



Resources and Handouts

- O and M of Pumps Manual
- JICA, Manual on sewerage and sewage treatment,
  Part B: Operation and Maintenance,
  Ministry of Urban Development, New Delhi

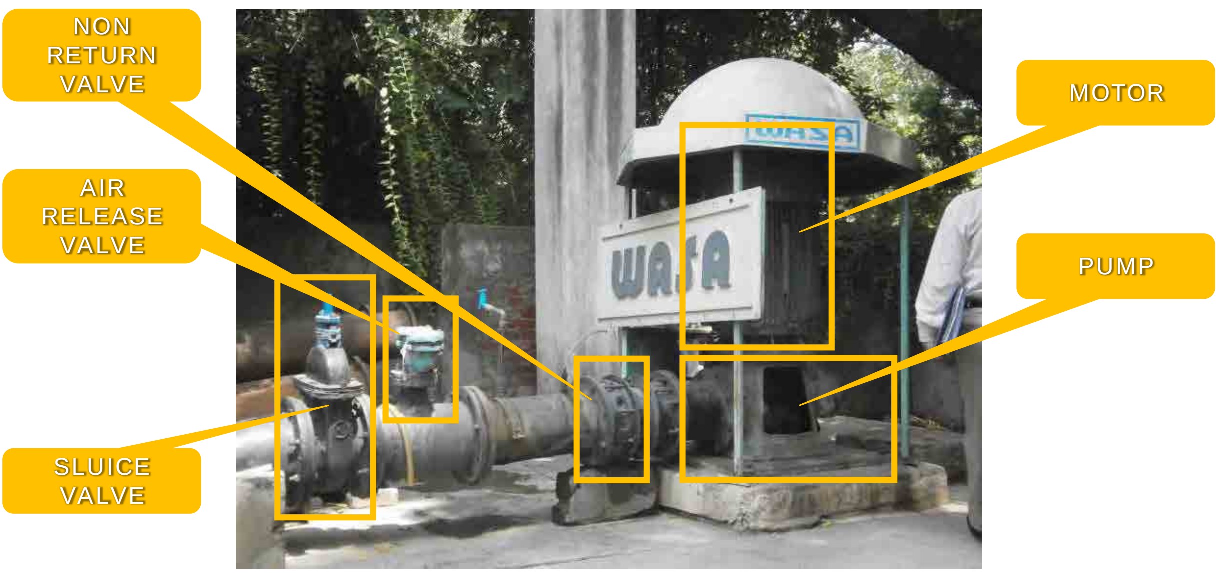
Importance of Tube Well Pumps

This could be my home !

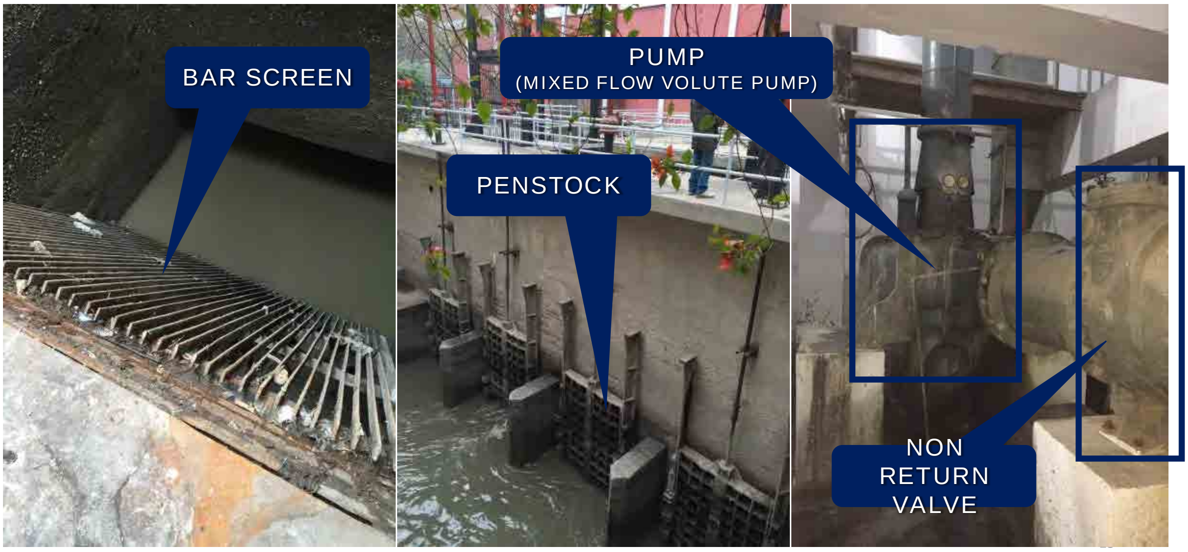
Importance of Disposal Station Pumps

This could be our children !

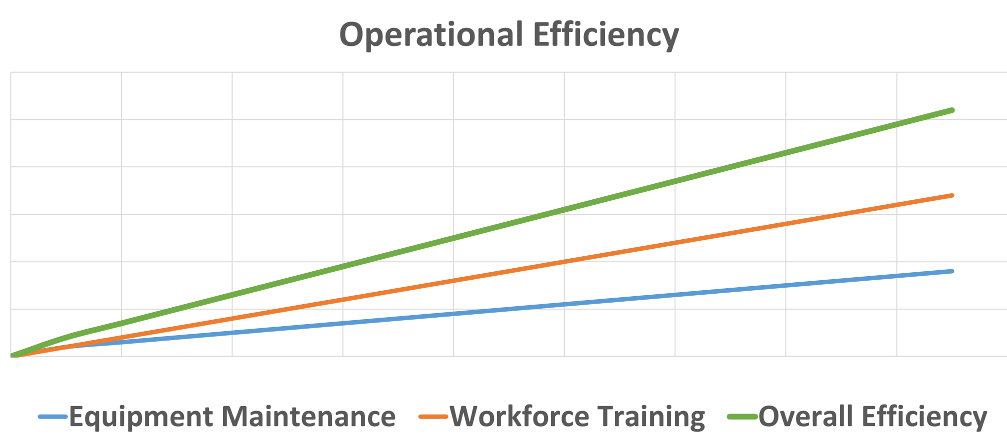
Introduction to Pumps (Tube Well)



Introduction to Pumps (Disposal Station)



Importance of Equipment Reliability and Trainings



Introduction to Pumps

Pump

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

Introduction to Pumps

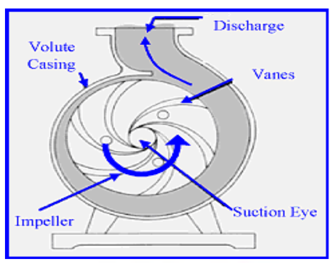
Two major categories:

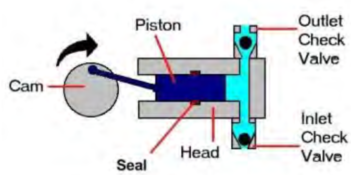
i) Centrifugal Pumps

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

ii) Positive Displacement Pumps

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



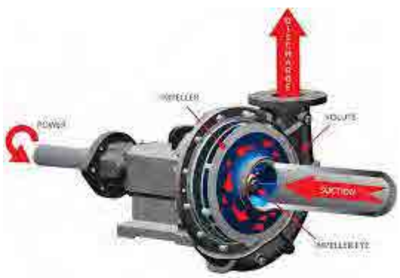


SINGLE ACTING RECIPROCATING

Introduction to Pumps

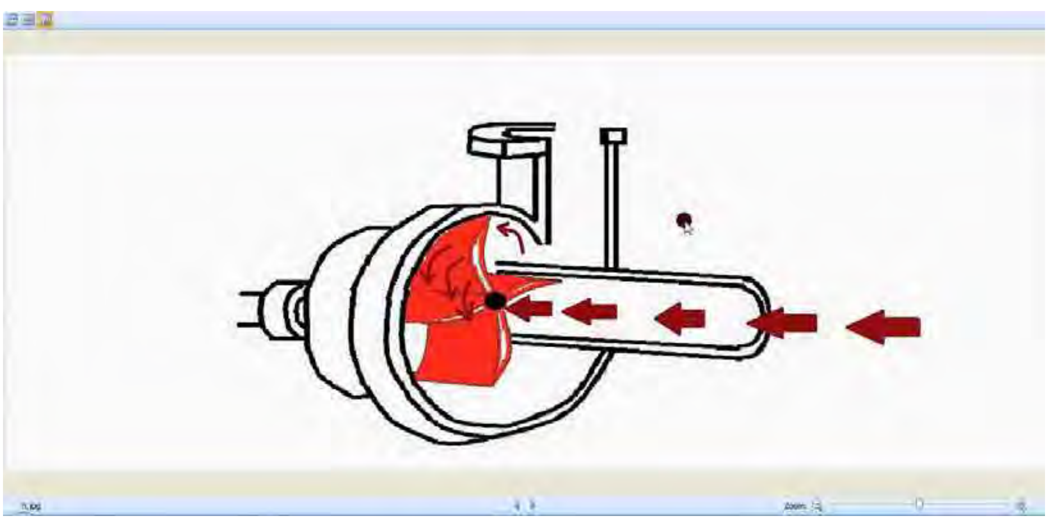
Centrifugal Pumps

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?

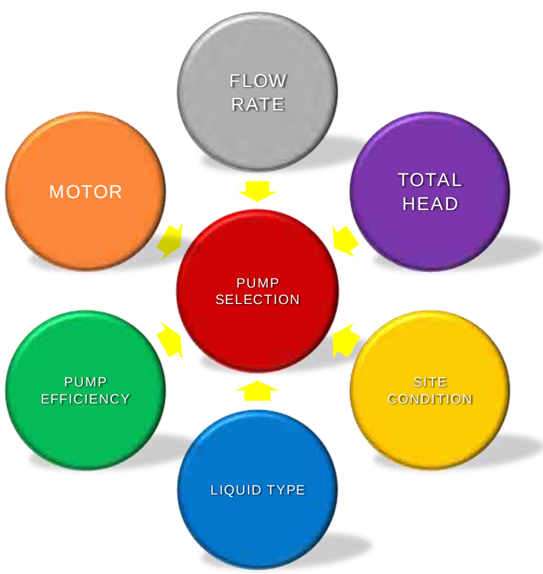
How far or high water will be delivered?

Is there a guaranteed pump efficiency need?

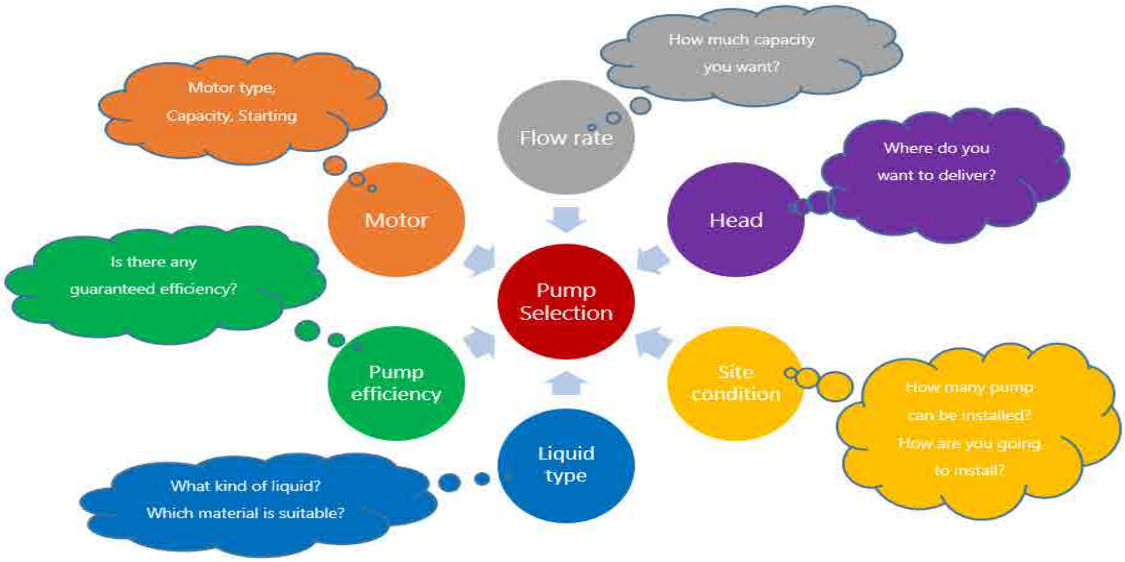
What kind of liquid is transported?

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

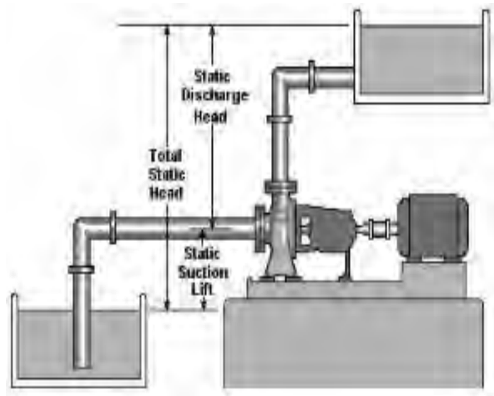
The following terms apply specifically to the analysis of pumps and pumping systems:

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

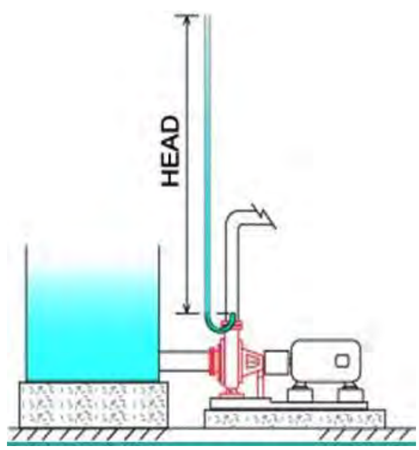
The term “head” is the elevation of free water surface of water above or below a reference datum. For example, if a small, open-ended tube were run vertically upward from a pipe under pressure, the head would be the distance from the center line of the pipe to the free water surface in the vertical tube.



Introduction to Pump Design Basics

Head

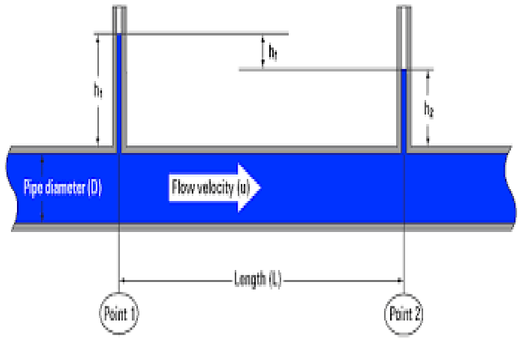
In pumping systems, the head refers to both pumps and pumping systems. The height to which a pump can raise the water is the pump head and it is measured in meters (feet) of flowing water. The head required to overcome the losses in a pipe system at a given flow rate is called the system head.



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:

$$\text{Velocity head} = \frac{V^2}{2g}$$

Introduction to Pump Design Basics

Total Head (TH)

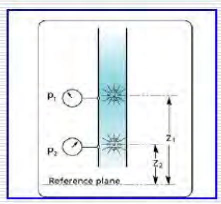
Total Head, is the head against which the pump must work when the water is being pumped. The TH, can be determined by adding total static head, the frictional head loss and pump losses.

TH = TSH+FH

PRESSURE & HEAD RELATIONSHIP

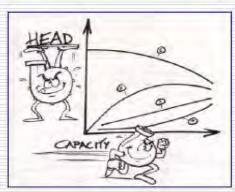
- Pressure (P) = SG x g x Head (H)
- **H = P / (SG x g)**
- **P = H x g x SG**

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



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

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



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

Conversion from head to pressure:

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

Conversion from pressure to head:

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

Introduction to Pump Design Basics

Pump Efficiency

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

Introduction to Pumps Types

Pump Efficiency

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

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

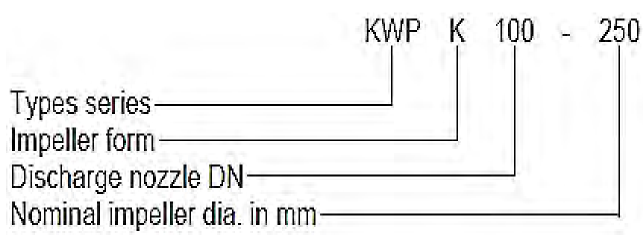
Specification:

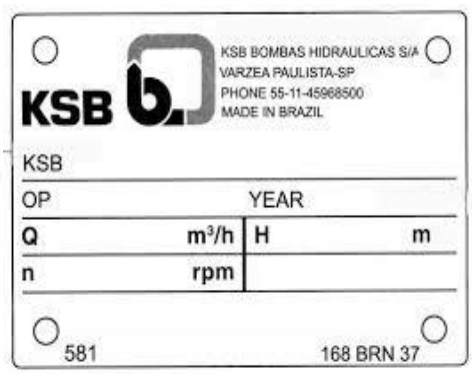
Discharge Diameter: 40--500mm(1.6--20inch)

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

Head: 6--80m

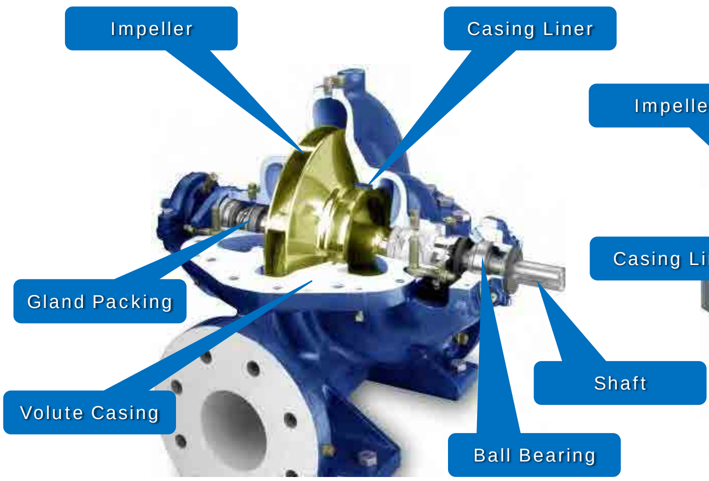
Name Plate and Designation



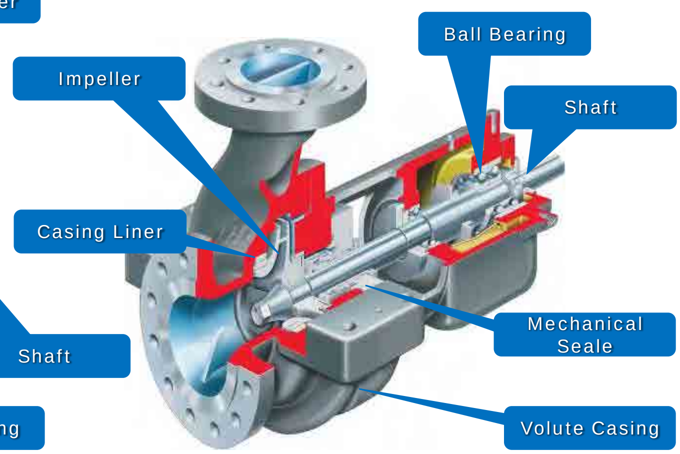


Assembly Parts of Pumps

Centrifugal Pump Structural Parts for Disposal Station



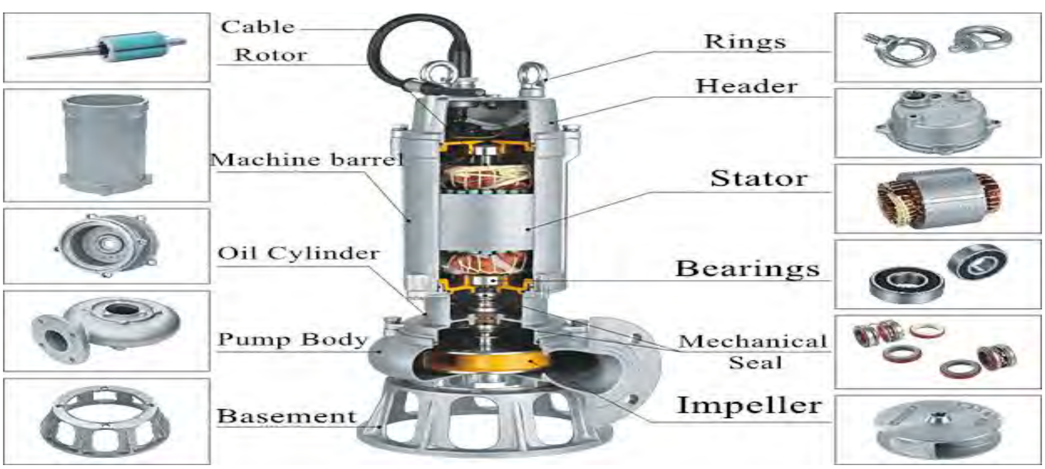
Double Suction Volute Pump



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

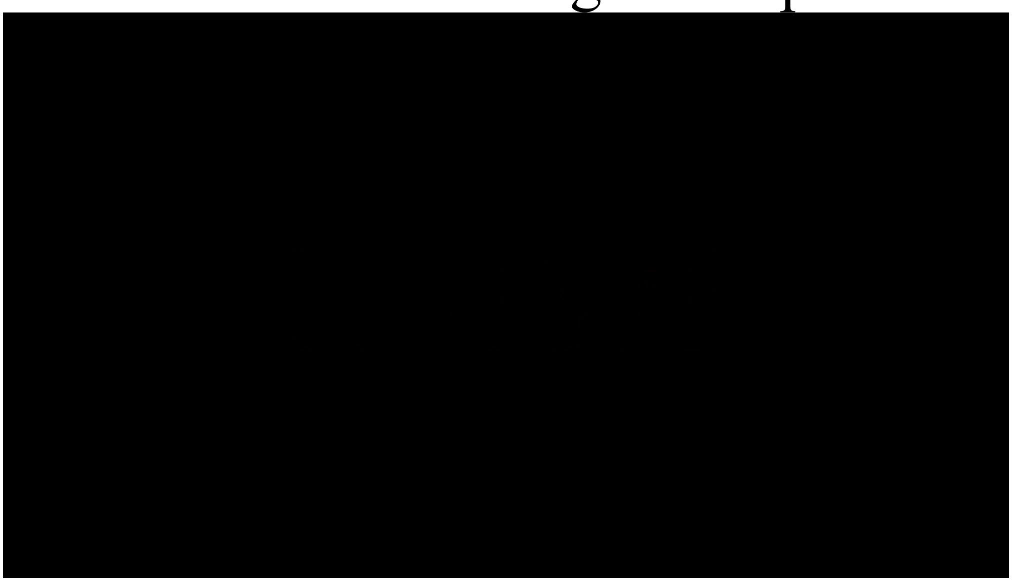
- Check that ammeter reading is less than rated motor current
- After startup check sump level (stable)
- Check for undue vibration and noise.
- After10-15 minutes, check the bearing temperature, stuffing box packing, and leakage through mechanical seal.
- Voltage should be checked every hour.

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



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

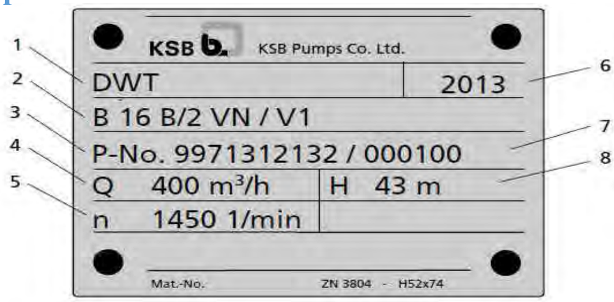
DesignationExample: B 16 B/2 VN / V1

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



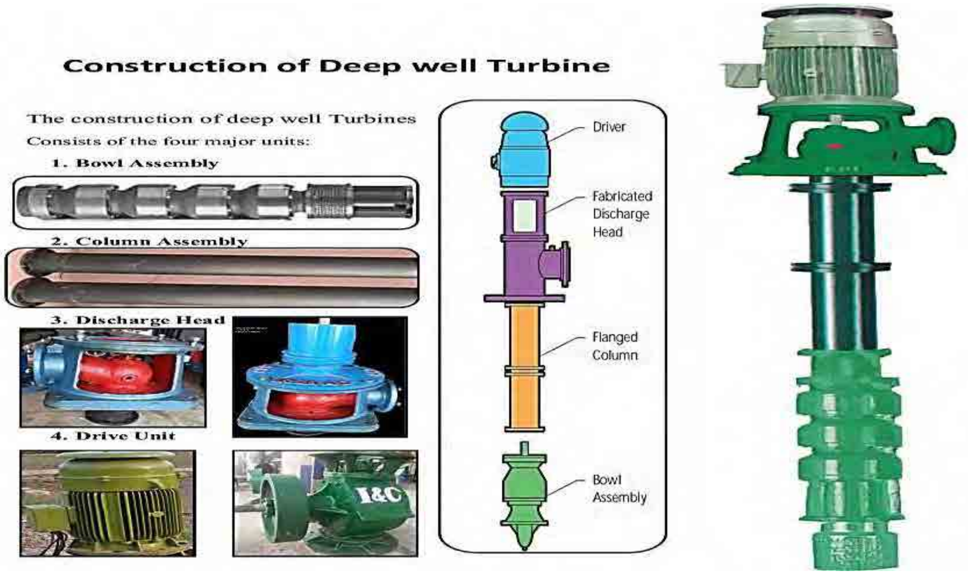
1	Pump type	2	Designation of the pump set
3	Order number	4	Flow rate
5	Speed	6	Year of supply
7	Order item number	8	Head

Introduction to Pumps Types

Submersible Pump

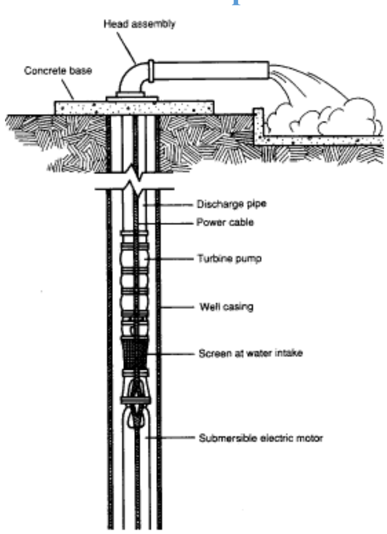
A type of pump in which the motor and pump both are in the ground water reservoir. Motor is water proof and electricity is provided to the motor by a water proof cable.

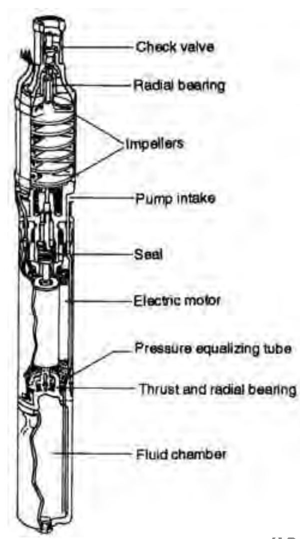
Assembly Parts of Pumps



Assembly Parts of Pumps

Structural Parts of Submersible Pump for Tube well





Comparison of Vertical pump and Submersible pump

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

Pumps Operations

Vertical Turbine Pump Startup & Operation

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

Pumps Operations

Vertical Turbine Pump Startup & Operation

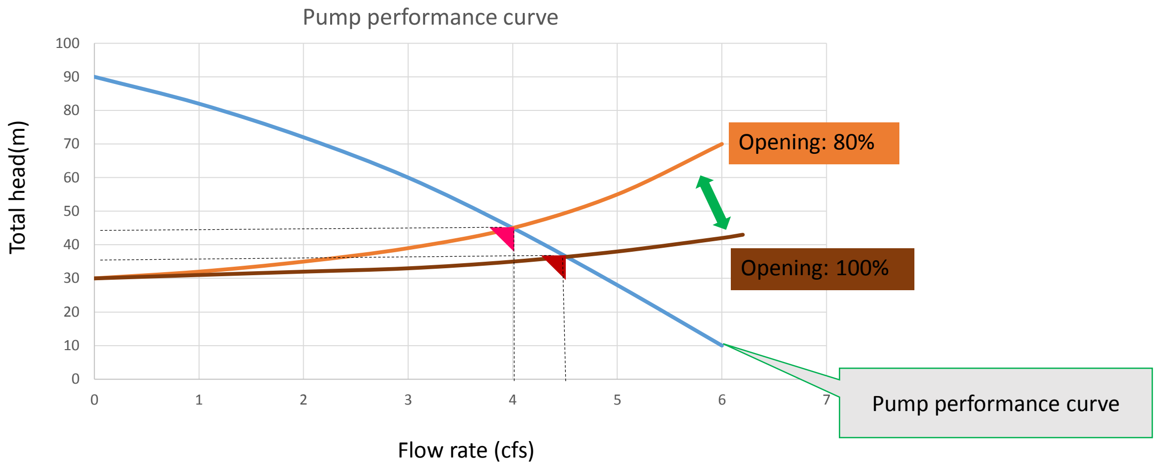
- After startup check pressure for operating point.
- Check for undue vibration and noise.
- After10-15 minutes, check the bearing temperature, stuffing box packing, and leakage through mechanical seal.
- Voltage should be checked every hour.

Pumps Operations

Submersible Pump Startup & Operation

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

Pumps Performance



Preventive Maintenance of Pumps

Preventive Maintenance Vertical Turbine Pumps

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

Preventive Maintenance of Pumps

Preventive Maintenance Pumps

Stuffing-box box leaks

✓ **Normal leaks**

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

✓ **Decreased leaks**

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

Regular Submersible Pump (Motor) Inspections

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

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

Insulating Testing for 3-Phase Motor

Step By Step Procedure for Insulation Testing

1. Turn off the main circuit breaker and check with multi-meter there are no voltages.
2. Perform continuity check using multi-meter across magnetic contactors K_1, K_2 and K_3 ensuring perfect isolation in off state.

Step By Step Procedure for Insulation Testing

1. Connect the terminals of insulation tester black with earth and red with U_1, V_1 and W_1 one by one with energize insulation tester and note values.
2. Cross winding insulation test

   Connect the terminals in the pattern

   $U_1 - V_1$, $U_1 - W_1$, $V_1 - W_1$ and

   $U_2 - V_2$, $U_2 - W_2$, $V_2 - W_2$

Energize the system and note down values. Minimum insulation resistance value should be more the 1 MΩ.

Troubleshooting

Trouble shooting Pumps

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

.

Troubleshooting

Trouble shooting Pump

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

Troubleshooting

Trouble shooting Centrifugal Pump

No liquid delivered

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

Troubleshooting

Trouble shooting Centrifugal Pump

Not enough water discharge

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

Troubleshooting

Trouble shooting Centrifugal Pump

Overloading of Motor / Engine

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

Troubleshooting

Trouble shooting Vertical Turbine Pump

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

Troubleshooting

Trouble shooting Vertical Turbine Pump

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

Troubleshooting

Trouble shooting Submersible Pump

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

Troubleshooting

Trouble shooting Submersible Pump

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

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

Troubleshooting

Trouble shooting Submersible Pump

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

Motor Size Calculation

Shaft Power Calculation

Pump efficiency (η):

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

Motor Size Calculation

Liquid power (L_w):

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

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

Where L_w : Liquid power $[kW]$

ρ : Liquid density $[kg/m^3]$

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

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

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

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

H : Total head [m]

Motor Size Calculation

Shaft power (L):

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

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

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

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

Power output determination

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

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

Suggested Improvement

WSD 5231, Module 1 73

Suggested Improvement

WSD 5231, Module 1 74

Suggested Improvements

WSD 5231, Module 1 75

Suggested Improvements

WSD 5231, Module 1 76

Suggested Improvements

WSD 5231, Module 1 77

Suggested Improvements

WSD 5231, Module 1 78

Current Conditions

Suggested Improvement

Current Conditions

Suggested Improvement

Suggested Improvement

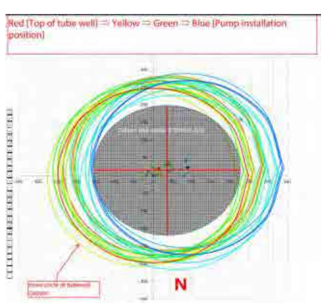
WASA Field Issues

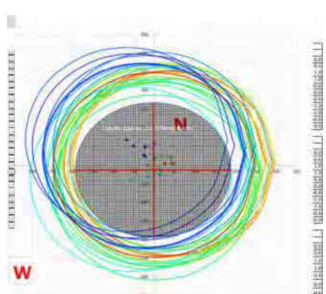
Water Level Indicator Usage Issue

Water Level Indicator Usage Issue

Water Level Indicator Usage Issue

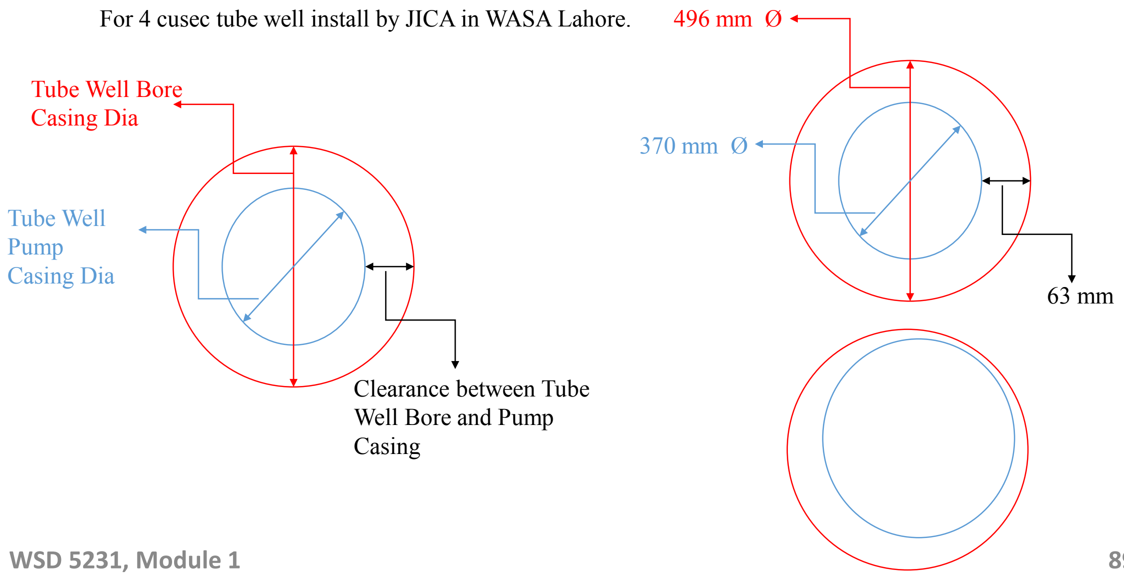
Water Level Indicator Usage Issue





Water Level Indicator Usage Issue

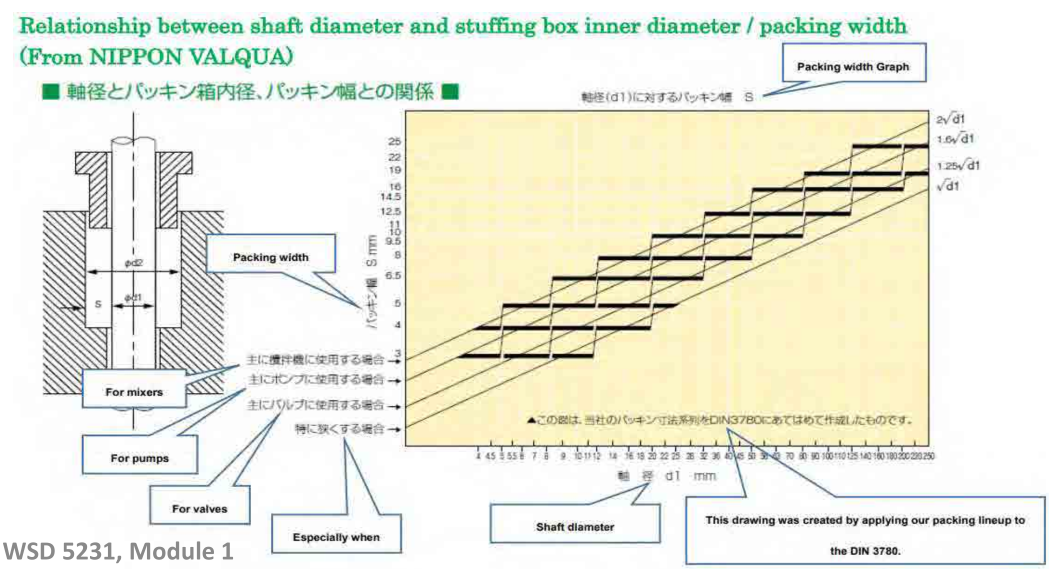
For 4 cusec tube well install by JICA in WASA Lahore.



Water Level Indicator Usage Issue

Standards Parts Usage Issue

Standards Parts Usage Issue



Rust issue on WASA Facility

Use of sand blasting to remove rust

Rust issue on WASA Facility

- Nuts and Bolt use SS bolts and nuts where applicable



Rust issue on WASA Facility

Valves maintenance issue in WASAs

Valves maintenance issue in WASAs

Valves maintenance issue in WASAs

- Material thickness are visual check for part durability

Valves maintenance issue in WASAs

- Cracked gasket

Valves maintenance issue in WASAs

- Absence of balls in air release valves

Lubricating box issue in WASAs

Lubricating box issue in WASAs

Lubricating box issue in WASAs

Chlorinator issue in WASAs

Water Filtration Plant Leakage

Backwash handle leakage due to undersize and crack O ring.

Filtration Plant Leakage

Filtration Plant Filter Media

5 Microns

1 Micron

Filtration Plant UV Lamp

Out of order
UV Lamp

Two Chlorinator Usage

Multi Gate Valves Usage

Valves Jammed Usage

Jammed
Ball Valve

Over-greasing Usage

Over
Greasing

Isolation valve location and Packing

Installation of Gland Packing

Gate Valve should be install outside of Pump House for isolation of system.

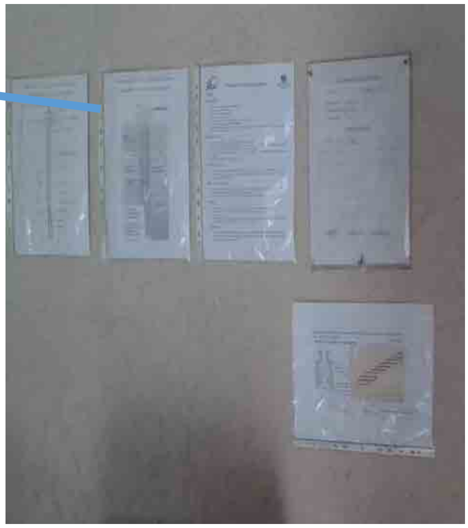
WASA Pump House Cleanliness and Hygiene

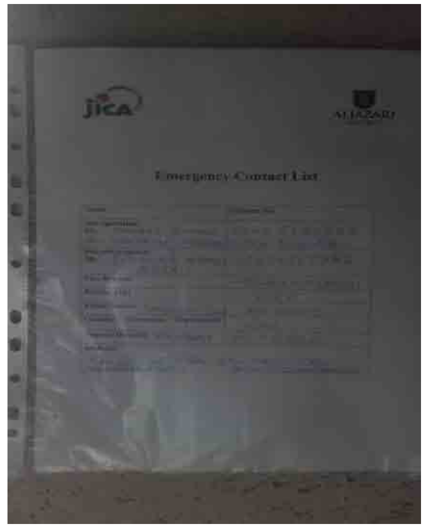
Cleaning at Pump house

Hygiene filter water supply

WASA Pump House Templates Issue

Template related to O&M of pump





Things to remember !!!

- ✓ **Follow SOPs**
- ✓ **Implement HSE and 5S**
- ✓ **Use standard parts**
- ✓ **Keep operational records**
- ✓ **Keep maintenance record**
- ✓ **Keep and refer manuals**
- ✓ **Plan, develop and implement preventive maintenance plans**

O & M of Mechanical Equipment
WSD 5231

Module 1

Valves

Icebreaker and Class Introduction

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

Agenda

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

Agenda

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

Icebreaker and Class Introduction

Now it is your turn…

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

Resources and Handouts

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

Resources and Handouts

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

Introduction and selection of valves

Valve

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

Valve Functions

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

Introduction and selection of valves

Classification of Valves

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

Linear Motion Valves.

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

Introduction and selection of valves

Classification of Valves

Rotary Motion Valves.

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

Quarter Turn Valves.

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

Introduction and selection of valves

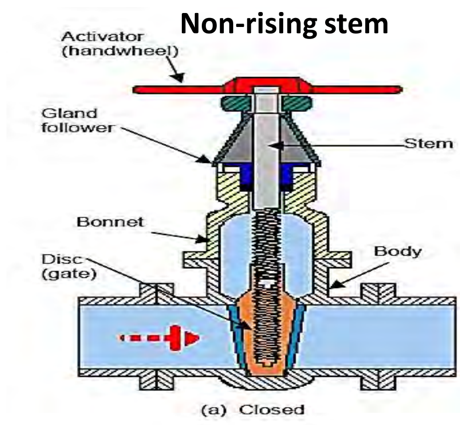
Classification of valves based on motion

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

Assembly parts of valves

Basic Parts of the valve

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



Assembly parts of valves

Basic Parts of the valve

Bonnet

The cover for the opening in the valve body joint.

Bonnets Features

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

Bolted Bonnet

Assembly parts of valves

Basic Parts of the valve

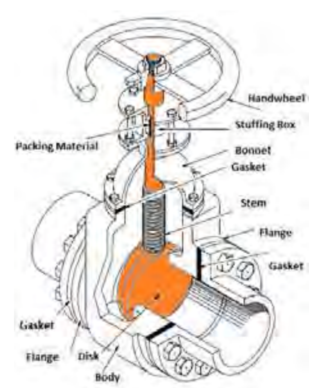
Body

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

Introduction and selection of valves

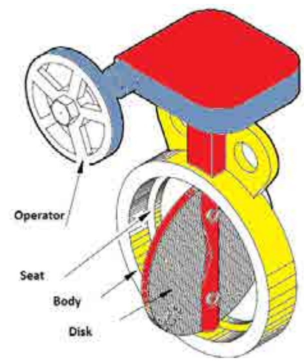
Methods of controlling flow through a valve.

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



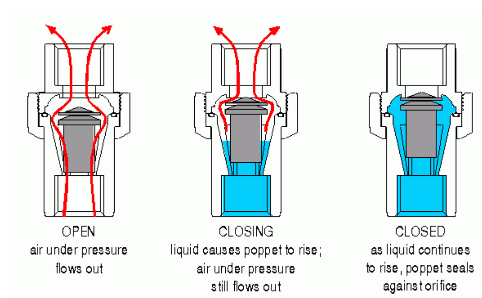
Gate valve

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



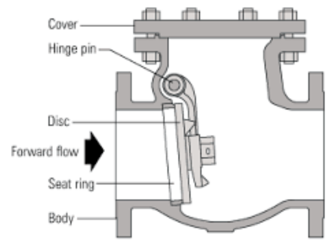
Butterfly valve

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



Air release valve

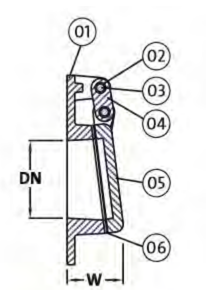
4. Non return valve rotates a disc to stop the backflow of the fluid



Non return valve

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

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



Flap valve

Valve Type and Material Selection

Selection Consideration

1. **Pressure**

2. **Temperature**

3. **Type of fluid**

    A. Water

    B. Wastewater (corrosive)

    C. Water with sand (abrasive)

4. **Flow Considerations**

    A. On-off or Throttling

    B. To prevent backflow

    C. Concern for pressure drop

    D. Velocity

    E. Flow resistance

5. **Operating conditions**

    A. Frequency of operation.

    B. Accessibility.

    C. Overall space/size available.

    D. Manual or automated control.

    E. Need for bubble-tight shut-off.

    F. Concerns about body joint leaks.

    G. Fire safe design.

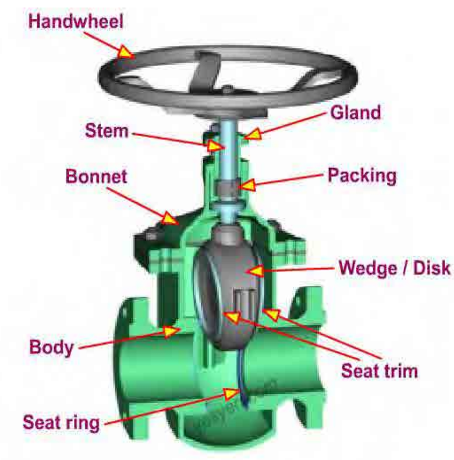
    H. Speed of closure.

Introduction and selection of valves

Valve Types

Gate Valves

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



Introduction and selection of valves

Valve Types

Gate Valves

Advantages

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

Introduction and selection of valves

Valve Types

Gate Valves

Disadvantages

It is not suitable for throttling applications.

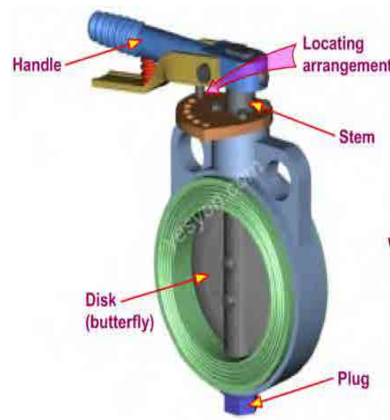
- It is prone to vibration in the partially open state.
- It is more subject to seat and disk wear.
- Repairs, such as lapping and grinding, are generally more difficult to accomplish.

Introduction and selection of valves

Valve Types

Butterfly Valves

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



Introduction and selection of valves

Valve Types

Butterfly Valves

Advantages

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

Introduction and selection of valves

Valve Types

Butterfly Valves

Disadvantages

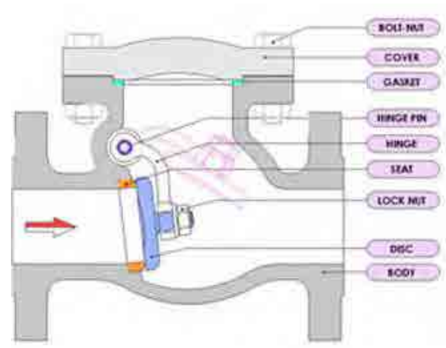
- Difficult to clean
- Throttling limited to low differential pressure
- Potential for cavitation and choke
- Unguided disc movement is affected by flow turbulence

Introduction and selection of valves

Valve Types

Check or Non return valve

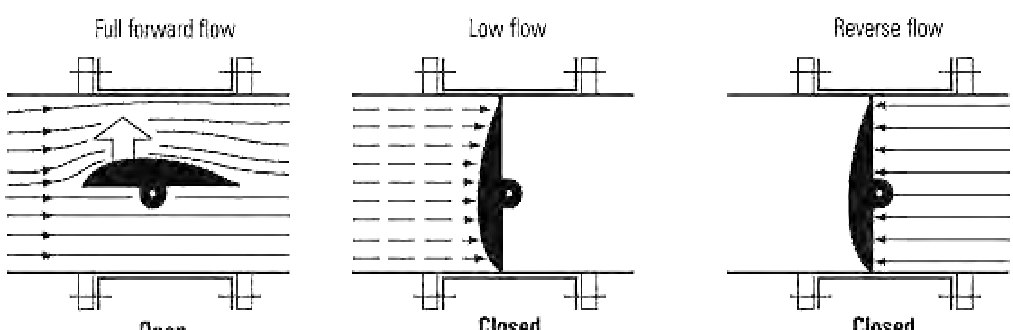
Check valves are designed to prevent the reversal of flow in a piping system. These valves are activated by the flowing material in the pipeline. The pressure of the fluid passing through the system opens the valve, while any reversal of flow will close the valve.



Introduction and selection of valves

Valve Types

Check or Non return valve



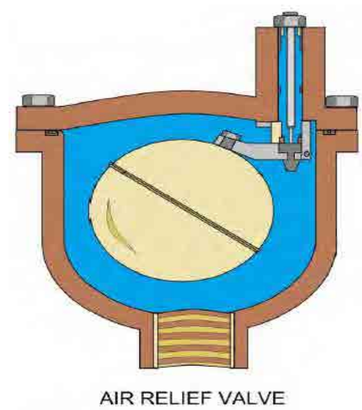
Tilting-disk Check Valve

Introduction and selection of valves

Valve Types

Air Release Valves

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



Introduction and selection of valves

Valve Types

Air Release Valves

Advantages

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

Introduction and selection of valves

Valve Types

Air Release Valves

Advantages

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

Disadvantages

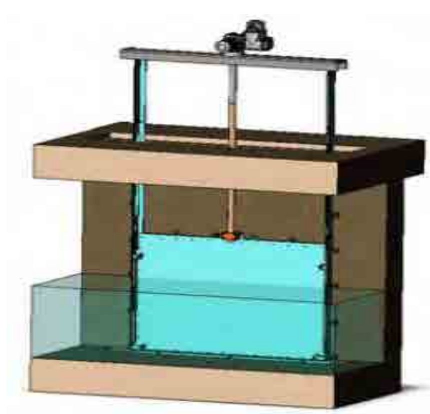
- If a pipeline is filled or emptied too quickly, an air release valve does not always keep up with the air flow demands.
- You must size the valve correctly for your application.

Introduction and selection of valves

Valve Types

Penstock Valve

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



Valves operations

Guidelines to close a valve

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

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

Valves operations

Guidelines to close a valve

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

Causes of Debris and Sediment valve

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

Preventive maintenance of valves

Valve Maintenance Procedures

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

Preventive maintenance of valves

Valve Maintenance Procedures

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

Date:

Exercise1A: Pump Selection Parameters

Participant Name:

Organization:

Contact Number:

Email:

Excise1: Pump Selection Parameters

Please connect related terms.

- Where do you want to distribute water?
- How much spaces can be available?
- Which materials are suitable? Is this suitable for drinking?
- Do you consider energy saving?
- How much water people need?
- Which starting method should be used?

- Motor
- Flow rate
- Head
- Liquid type/quality
- Pump efficiency
- Site condition

- WHO guidelines
- Water level
- kW, Voltage, Frequency
- %, energy consumption
- cfs, m3
- m2, land purchase

Please discus other pump selection parameters with the reasons.

Excise1: Pump Selection Parameters (Solution)

Please connect related terms.

- Where do you want to distribute water?
- How much spaces can be available?
- Which materials are suitable?
  Is this suitable for drinking?
- Do you consider energy serving?
- How much water people need?
- Which starting method should be used?

- Motor
- Flow rate
- Head
- Liquid type/quality
- Pump efficiency
- Site condition

- WHO guidelines
- Water level
- kW, Voltage, Frequency
- %, energy consumption
- cfs, m3
- m2, land purchase

Please discus other pump selection parameters with the reasons.

Date:

Exercise1B: Head Calculations

Participant Name:

Organization:

Contact Number:

Email:

Exercise 1-1:

Please select a right Static head for Tube well pump from A to D(Fig.1).

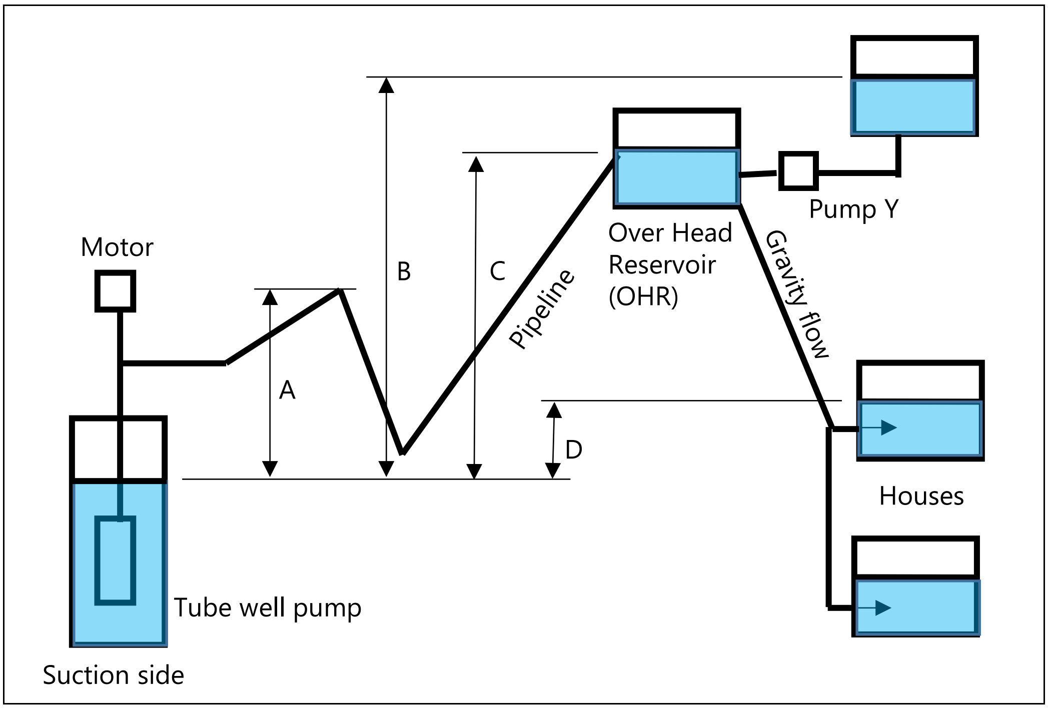


Fig.1 Static head examination

Exercise 1-2:

When site condition for booster pump station is shown below, how much total head is required for the pump (Fig 2).

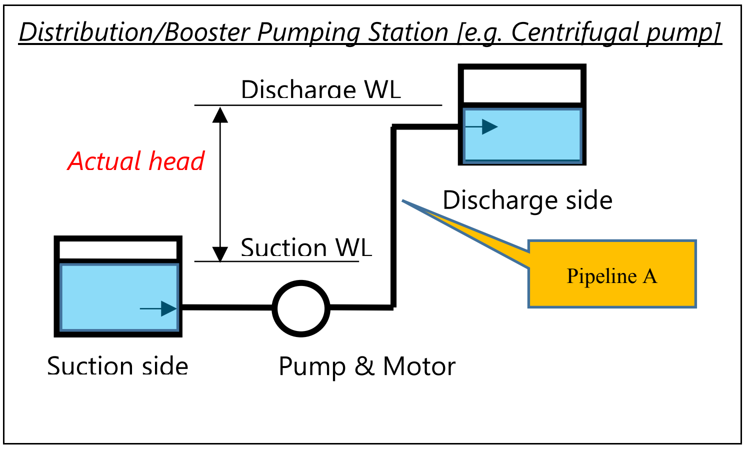


Fig 2 Actual head examination

Pump around losses	: 2 m
Suction WL	: +5.0m
Discharge WL	: +25m

Note: Water level does not change during pump operation

Length of pipeline A	: 1000 m
Pipe friction loss	: 9.3m
Pipe inner diameter	: 600 mm
Flow rate	: 50 m^3/min
Static head	: 20m

Exercise 1-3:

Please calculate total head.

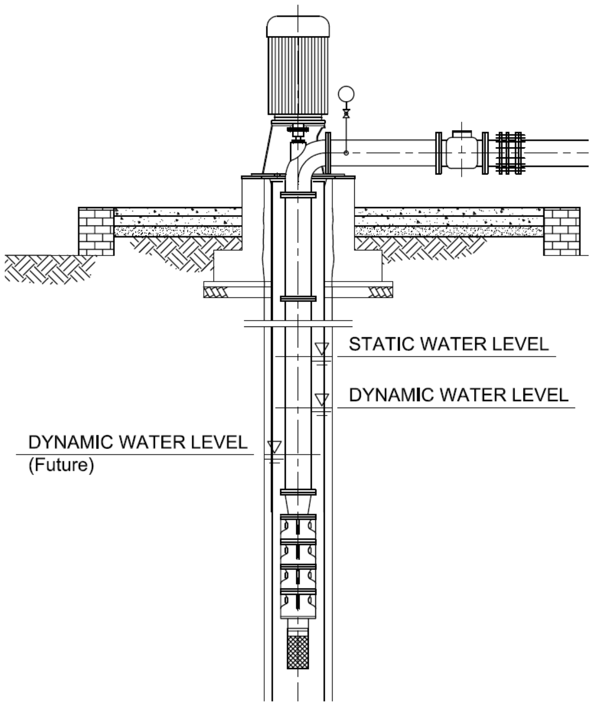


Fig. 3.5 General arrangement of tube well

Note: The tube well pump shall be installed under future dynamic water level that is decided that based on estimated annual water table drawdown, deterioration of tube well and pump replacement schedule etc.

・Pressure gauge reading: 0.1 MPa (approx.10m head)

・Current static water level: 40 m from ground level

・Current dynamic water level: 45 m from ground level

・Pump losses(suction loss, etc.): 5 m

Exercise 1-4:

Please calculate pump installation depth.

・Current static water level: minus 40 m from ground level.

・Pump life cycle (replacement schedule) : 15 years

・Annual water table drawdown: approx. 1m

・Difference of static water level to dynamic water level after 15 years: approx. 5m

Exercise1-1:

Please select a right Static head for Tube well pump from A to D(Fig.1).

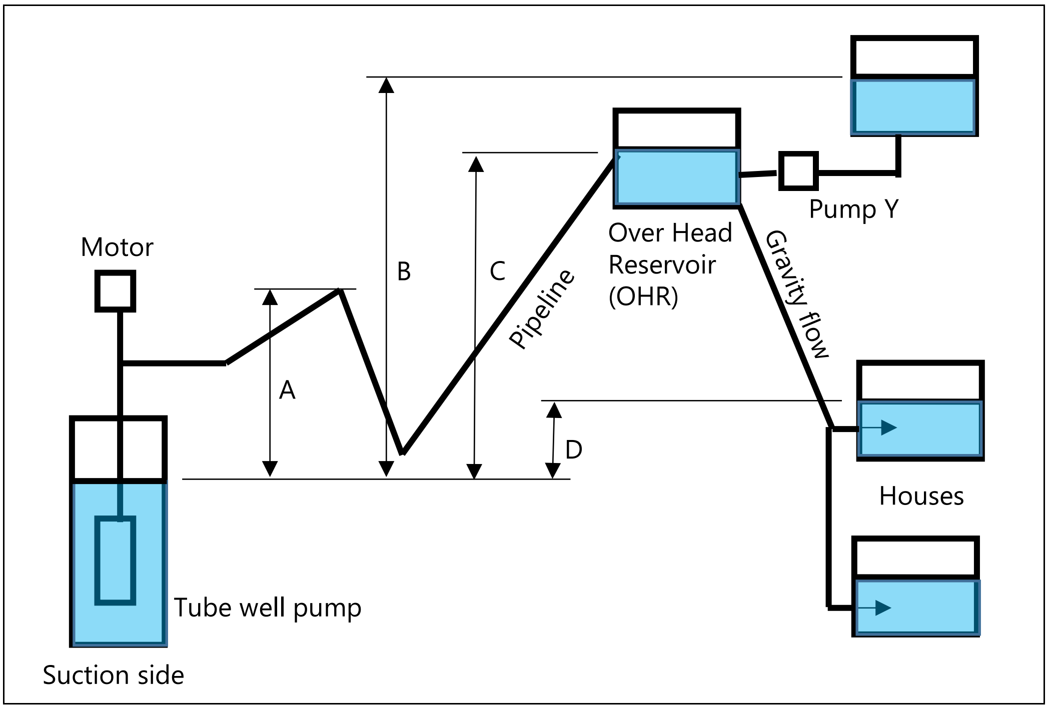


Fig.1 Static head examination

Answer: C

Exercise1-2:

When site condition for booster pump station is shown as below, how much total head is required for the pump(Fig 2).

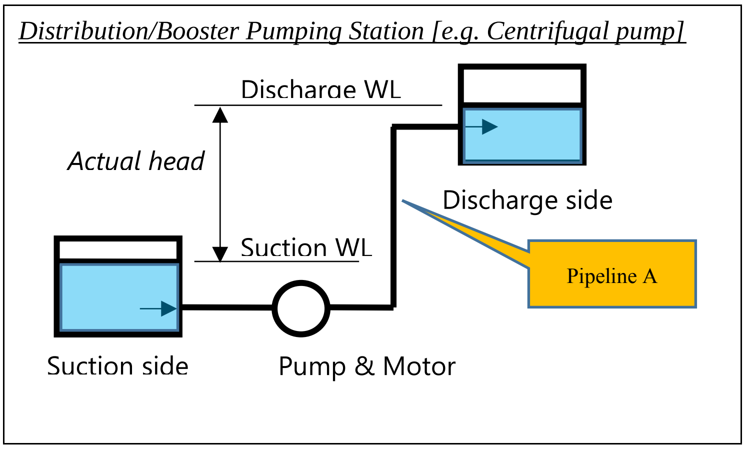


Fig 2 Actual head examination

Pump around losses : 2 m

Suction WL : +5.0m

Discharge WL : +25m

Note: Water level does not change during pump operation

Length of pipeline A : 1000 m

Pipe friction loss : 9.3m

Pipe inner diameter : 600 mm

Flow rate : 50 m^3/min

Static head : 20m

Answer:

Total head=Static head (20m) + Pipe friction loss (9.3m) + Pump around(2m) = : 31.3m

Exercise 1-3:

Please calculate total head.

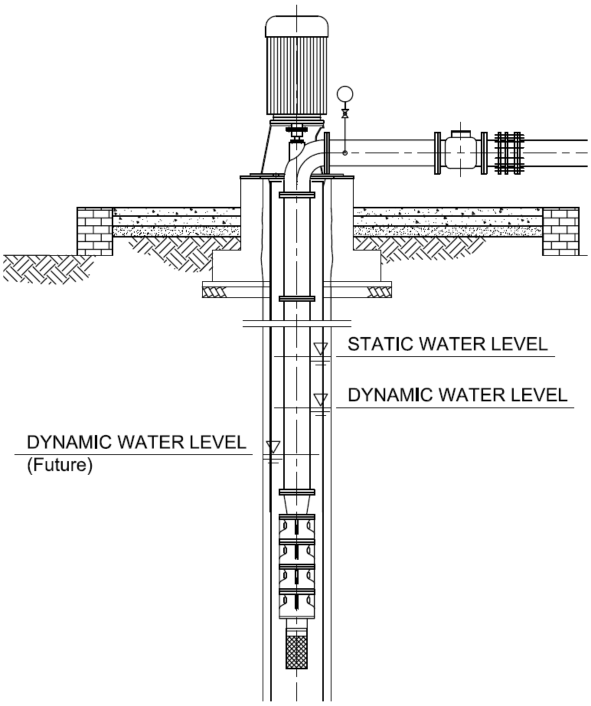


Fig. 3.5 General arrangement of tube well

・Discharge pipe head loss: 10m

・Current static water level: 40 m from ground level

・Current dynamic water level: 45 m from ground level

・Pump losses(suction loss, etc.): 5 m

Answer:

Pump total head = Discharge head loss(10m) + Current Dynamic water level(45m) + Pump losses = 60m.

Exercise 1-4:

Please calculate pump installation depth.

t

・Pump life cycle (replacement schedule) : 15 years

・Annual water table drawdown: approx. 1m

・Difference of static water level to dynamic water level after 15 years: approx. 5m

Answer:

Pump shall be installed minus 60 m from ground level.

Pump shall be installed under water level even after 15years

Installation level = Current water level(40m) + expected drop down of water table for 15years (15m) + dynamic water level drop down after 15years(5m) = 60m

Course: ______________________________

Module: ______________________________

Training Date: ________________________

Trainee: ______________________________

Organization: _________________________

Email: _______________________________

Contact #: ____________________________

Module 1, Exercise 2

Question:
Please indicate all one year maintenance items (refer to O & M manual, find the relative manual sections and select maintenance items).

TITLE	**INSTRUCTION MANUAL FOR PUMP**	DOC. No. E113016/1210/0135	REV. 0
PROJECT NAME	**URGENT REHABILITATION PROJECT FOR SEWERAGE & DRAINAGE SYSTEM IN LAHORE**	COMPLETE IN SHEETS WITH COVER	**34**
CUSTOMER	**WASA**		
ITEM No.	**P1-1, P3-1, P4-1**	EHD SER. No.	**E113016-01, 03, 04**
SERVICE	**SEWAGE PUMP**	MODEL/ EQUIP. **700VLYM**	**SET 14**

Module 1, Exercise 2

Refer to appropriate O & M manual section

Module 1, Exercise 2

Refer to appropriate O & M manual section and check the items below

JICA — Disposal Station Pump Maintenance Schedule — ALJAZARI ACADEMY

EBARA 700VLYM

Sr. No.	Maintenance Item	Daily	Weekly	Monthly	6 Months	1 Year	2 Years
1	Suction and Discharge pressure						
2	Current values (ammeter)						
3	Bearing temperature						
4	Vibrations						
5	Stuffing box inspection (if leakage exists, tighten the gland gradually and evenly. Please refer manual for more details)						
6	Gland packing replacement (when excessive leakage or see manual for interval)						
7	Auxiliary piping system						
8	Bearing lubrication (refer table 5.2 to calculate days, assume pump operates 12 hours a day)						
9	Disassembly inspection (please refer table 5.3 for part replacement intervals)						
10	Maintenance during prolonged stoppage						
11	Replace bearings (refer table 5.2 to calculate days, assume pump operates 12 hours a day)						
12							
13							

Module 1, Exercise 2 (Solution)

Refer to appropriate O & M manual section and check the items below

Disposal Station Pump Maintenance Schedule

EBARA 700VLYM

Sr. No.	Maintenance Item	Daily	Weekly	Monthly	6 Months	1 Year	2 Years
1	Suction and Discharge pressure	●					
2	Current values (ammeter)	●					
3	Bearing temperature	●					
4	Vibrations	●					
5	Stuffing box inspection (if leakage exists, tighten the gland gradually and evenly. Please refer manual for more details)	●					
6	Gland packing replacement (when excessive leakage or see manual for interval)					●	
7	Auxiliary piping system	●					
8	Bearing lubrication (refer table 5.2 to calculate days, assume pump operates 12 hours a day)					●	
9	Disassembly inspection (please refer table 5.3 for part replacement intervals)						●
10	Maintenance during prolonged stoppage			●			
11	Replace bearings (refer table 5.3)						●
12							
13							
14							

4.3 Power Failure and Emergency Stop

(1) In the event that the pump has stopped due to a power failure, first turn the electrical source switch off, and then close the discharge valve.

(2) In the event of an emergency stop, cut the power supply of the driver and close the discharge valve.

5. Maintenance

To maintain good pump operation, carry out the following maintenance and checks.

⚠**WARNING** : *During pump operation, do not touch rotating parts of the pump. keep hands, hair and tools away from these parts to prevent serious accidents.*

⚠**WARNING** : *Cut the power supply so the driver cannot be started by mistake after pumping stop.*

⚠**CAUTION** : *Drain pump and piping as they might crack when internal water freezes while pumping stop in winter, etc.*

5.1 Daily Checks

If pressure, current, vibration and noise, etc. are extremely different from normal value, an immediate investigation is required because it is a sign of an impending trouble. An operation log should be kept for this purpose.

5.1.1 Suction and Discharge Pressures, Current Values

Check the values of the suction and discharge pressure gauges, and ammeter values for any swings. Valves on pressure and compound gauges should be opened only when measurements are taken. If they are kept open at other times, the instruments may be damaged by dynamic pressure or other causes.

5.1.2 Bearing Temperature

Do not worry about the temperature of a bearing housing when the bearing housing can be touched, but measure temperature by installing a thermometer if it can not be touched.

Table 5.1 indicates the allowable temperature of a bearing housing surface with lithium base lubricating grease.

Table 5.1

Allowable temperature rise (At ambient temperature of not more than 40 ℃)	Allowable maximum temperature
55 ℃	90 ℃

5.1.3 Vibration

When vibration is larger than normal value, check for the alignment of coupling, improper piping, loose anchor bolts, etc.

5.1.4 Check Stuffing Box Portion

Check of leakage amount from gland, and adjust the leakage from the gland packing. When leakage is excessive, tighten the gland gradually and evenly. When the temperature is too high, loosen the gland to allow more leakage. After running the pump for a while to fit the shaft, tighten the gland again.
If excessive leakage occurs and cannot be adjust even by tightening the gland bolt units, replace the packing. Take care during replacement, as packing incorrectly installed will cause continuous leakage or partial abrasion of the sleeve.

5.1.5 Auxiliary Piping System

Confirm that all valves in the auxiliary piping are properly operating.

5.2 Periodic Inspections

5.2.1 Replenishment and Replacement of Bearing Lubricant

After starting operation, refill the grease by the amount and at the intervals as shown in Table 5.2 using the following procedure.
(1) While the pump is operating, open the grease outlet below the bearing.
(2) Grease is supplied through the grease nipple on the top of the bearing housing with a grease gun. The required quantity of grease per bearing is the quantity shown in Table 5.2.

NOTE: *Excessive grease can raise the temperature of bearing.*

(3) Overhaul the bearing every two years, and replace the old grease. In this case, charge each ball of bearings (as shown in Fig.5.2) with grease charging amount shown in Table 5.2.
Recommended Grease: JIS K2220 Grease Class 1 No.2 for anti-friction bearing (lithium base grease NLGI GRADE 2)

Table 5.2

	Replenishment		Exchange
	Quantity per pump	Interval	Quantity per pump
UPPER BEARING	230 cc	4300 hours	700 cc
LOWER BEARING	190 cc	4300 hours	580 cc

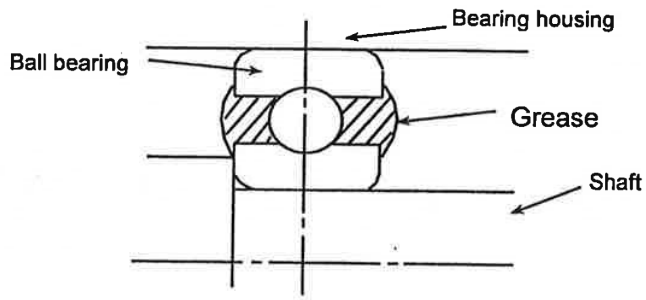


Fig. 5.2

5.2.2 Disassembly Inspection

Perform the disassembly inspection annually or once every two years depending on the operating conditions. At such times, it is desirable that the interior of the suction pit also be cleaned.

During the disassembly inspection, always take photographs showing a scale and make records of the condition of the parts. Each part is to be inspected.

Please refer to Table 5.3. The approximate intervals of replacement indicate standard periods of time in which the pump is operated under normal conditions.

Table 5.3

Part name	Replacement interval	Approximate replacement interval
Gland packing	When water (liquid) leakage is excessive	Once a year
Bearing	When abnormal sound occurs or the bearing sounds loud	Every two years
Packing Sleeve	When the surface of the sleeve is worn	Every two years
Casing ring	When the surface of the liner is worn	Every two years
Oil seal	When there is excessive lubricant leakage	Every two years
O- ring		Whenever the pump is disassembled
Gasket		Whenever the pump is disassembled

(1) Coupling and keys
Examine all keys for wear and damage. Ensure that they are flat, parallel and free from burrs, and properly fit the key way. Replace if necessary.

(2) Washers
Lock washers must function properly at all times. Therefore, any which have deteriorated must be replaced.

5.2.3 Maintenance During Prolonged Stoppage

The pump should be maintained so that it may be operated at any time. If possible operate the pump once a month.

Insulation of the motor will deteriorate when there is high humidity. Take care to keep the motor dry.

Daily Operation Record (Disposal Pumping Station)

Site :

Year :

Date / Month:

Pump : Flow Rate:

Total Head:

Motor Output:

Voltage:

Ampere:

Diaphragm pump:

Approved by (Engineer)	
Prepared by (Operator)	

Inspection	No.	Items	Unit	Date/time										Frequency	Total
Operating Condition	1	Operating Time	-	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :		
	2	Operating Hours	hrs.												
	3	Suction Pressure Gauge Reading (A few minutes after pump started)	Bar											every	
	4	Suction Pressure Gauge Reading (Before stop)	Bar											every	
	5	Discharge Pressure Gauge Reading (A few minutes after pump started)	Bar											every	
	6	Discharge Pressure Gauge Reading (Before stop)	Bar											every	
	7	Voltage	V											every	
	8	Ampere	A											every	
Visual Inspection	9	Cleanliness	Y / N											1/day	
	10	Gland Leakage	Nor/ High											1/day	
	11	Motor heating	Nor/ High											1/day	
	12	Motor Sound/Noise	Nor/ High											1/day	
	13	Non Return Valve Leakage	Y / N											1/day	
	14	Gate Valve Leakage (Inlet, Outlet)	Y / N											1/day	
	15	Flap Valve Leakage	Y / N											1/day	
	16	Gland Flushing water leakage	Y / N											1/day	
	17	Screen Clogging	Y / N											1/day	
	18														

Daily Operation Record (Tubewell Pumping Station)

Site :

Year :

Date / Month:

Pump : Flow Rate: Voltage:

Total Head: Ampere:

Motor Output: Diaphragm pump:

Approved by (Engineer)	
Prepared by (Operator)	

Inspection	No.	Items	Unit	Date/time										Frequency	Total
Operating Condition	1	Operating Time	-	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :		
	2	Operating Hours	hrs.												
	3	Diaphragm Pump %	%												
	4	Flow Meter Reading (Before start)	m^3											every	
	5	Flow Meter Reading (After Stopped)	m^3											every	
	6	Flow Amount (No.5 - No.4)	m^3											every	
	7	Pressure Gauge Reading (A few minutes after pump started)	Bar											every	
	8	Pressure Gauge Reading (Before stop)	Bar											every	
	9	Voltage	V											every	
	10	Ampere	A											every	
Visual Inspection	11	Cleanliness	Y / N											1/day	
	12	Gland Leakage 6L/hr(20drops/min)	Nor/ High											1/day	
	13	Motor heating	Nor/ High											1/day	
	14	Pump/Motor Noise and Vibration	Nor/ High											1/day	
	15	Non Return Valve Leakage	Y / N											1/day	
	16	Gate Valve Leakage	Y / N											1/day	
	17	Air Release Valve Lekage/Clogging	Y / N											1/day	
	18	Chlorine Storage	Y / N											1/day	

Equipment Evaluation Sheet for Mechanical Facility (Disposal pumping station)

Pump Specification				
Rated Flow Rate [m]	Rated Total Head [m]	Rated Motor Output [kW]	Rated Voltage [V]	Rated Ampere [A]

Site Name

Sub division

Equipment No.	Inspection Date	Inspected by	Approved by	Inspection Items for Mechanical Facilities													
				Common				Pump				Motor		Valves			Screen
				Operation Record	Drawings	Vender Manual	Cleanliness	Flow Rate	Gland Leakage	Pressure Gauge	Flashing Pipe	Noise/Sound	Voltage/Ampere	Non Return/Flap Valve	Gate Valve	Air Release Valve	Screening
				Compare with the sample	General arrangment, Sectional, Data sheet, Performance curve	Pump/Flowmeter/Valves/Diaphragm pump	No dust, sand, spider's nest, insect, small animals	Dischage amount is within 80%-120%of Rated	Leakage amount is within spec	Working properly	Working properly	Volums are within spec	Volums are within spec	Leakage or othe defect	Leakage or othe defect	Leakage or othe defect	Clogging or other defect
1																	
2																	

- Remarks -

Please make note here if anything unusual or you did some corrective actions.

Site conditions in detail shall be mentioned here with relevant Code Number.

(Noise, Overheat, Vibration, Foreign Object, Moisture, Dust, Sandy etc.)

Evaluation Criteria

✓ : Good / Yes

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

△ : Need to be improved

— : Not available to be checked

Equipment Evaluation Sheet for Mechanical Facility (Tubewell pumping station)

Site Name ______________ **Equipment Name** ______________

Sub division ______________

Evaluation Criteria

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

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

Code	Inspection Date	Inspected by	Approved by	Pump Specification					Inspection Items for Mechanical Facilities													
									Common				Pump			Motor		Valves			Diaphragm Pump	
				Rated Flow Rate	Rated Total Head	Rated Motor Output	Rated Voltage	Rated Ampere	Operation Record	Drawings	Vender Manual	Cleanliness	Flow Rate	Gland Leakage	Pressure Gaug	Vibration	Voltage/Ampere	Non Return Valve	Gate Valve	Air Release Valve	Diaphragm Pump	Flowmeter
				(m3/h)	(m)	(kW)	(V)	(A)	Received	General arrangment, Sectional, Data sheet, Performance curve	Pump/Flowmeter/Valves/Diaphragm pump	No dust, sand, spider's nest, insect, small animals	Discharge amount is within 80%-120%of Rated	20drps/mint Leakage amount is within spec	Working properly	Volums are within spec	Volums are within spec	Leakage or othe defect	Leakage or othe defect	Leakage or othe defect	Working properly	Working properly
1																						
2																						

- Remarks -

Please make note here if anything unusual or you did some corrective actions.

Site conditions in detail shall be mentioned here with relevant Code Number.

(Noise, Overheat, Vibration, Foreign Object, Moisture, Dust, Sandy etc.)

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?

WSD 5231, Mod 2 5

Icebreaker and Class Introduction

Now it is your turn…

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

  Chlorination and Filtration System?

WSD 5231, Mod 2 6

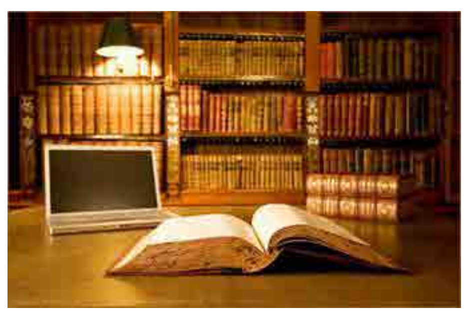
Icebreaker and Class Introduction

Now it is your turn…

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

Resources and Handouts

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



Introduction to Chlorination and Filtration Systems

Chlorine Disinfection (Chlorination)

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

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

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

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

There are two type of chlorinator which is used in WASA

1. Hypo Chlorinator

2. Drip Type Chlorinator

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

1. Hypo-chlorinator

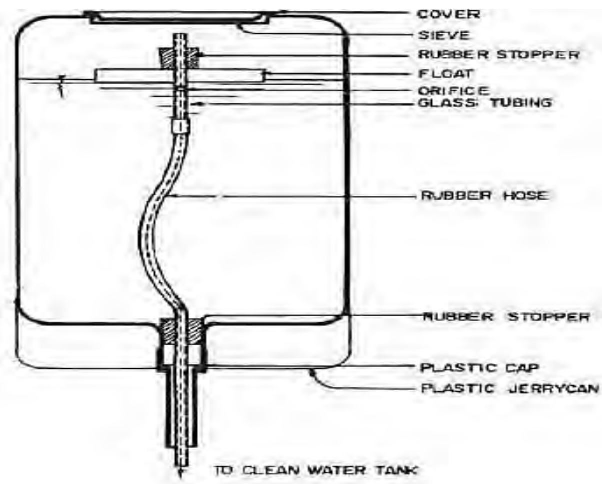
The hypo-chlorinator is a pump used to add hypochlorite solutions to water at a manually adjustable feeding rate. Pump draws the hypochlorite solution from a container and transfers it into the water for treatment.

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

1. Drip-type chlorinator

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



Introduction to Chlorination

Chlorine Disinfection (Chlorination)

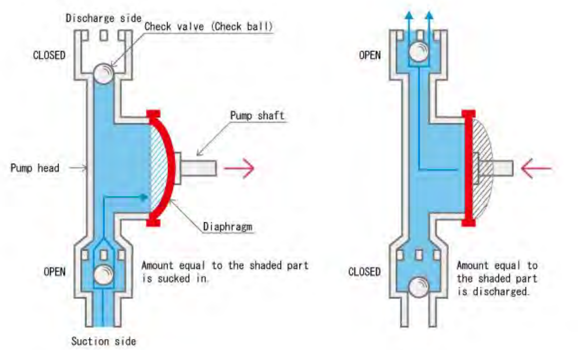
Diaphragm pump in chlorinator

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

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

Flow Diagram of Diaphragm Pump



Introduction to Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump characteristics:

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

Introduction to Chlorination

Chlorine Disinfection (Chlorination)

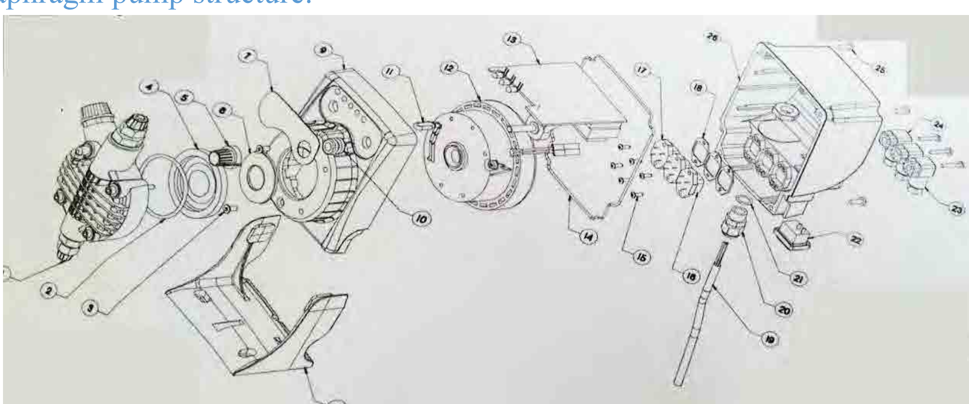
Diaphragm pump properties:

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

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump structure:



Structure of Diaphragm Pump

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Names of Parts:

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

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Main Components:

Main Component

Control Unit

Pump Head O-ring

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Main Components:

PTFE Diaphragm

Main component

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Main Components:

Thermostat/Electromagnet

Head,Drain,suction,Discharge points

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Main Components:

PTFE (polytetrafluorethylene)

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

PTFE

Assembly components of Chlorination

Chlorine Disinfection (Chlorination)

Diaphragm pump Main Components:

Non Return Valve

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

Non Return Valve

Assembly components of Chlorination

Chlorination system used in WASA tube well

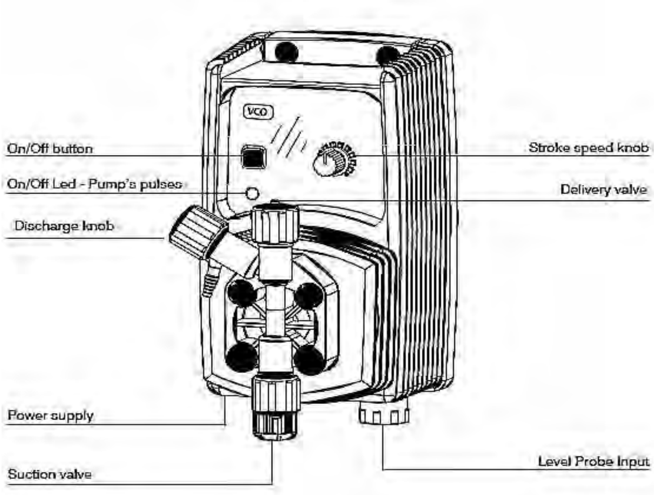
WASA use different types feed pumps for chlorine supply, most common are

a) EMEC V Pump

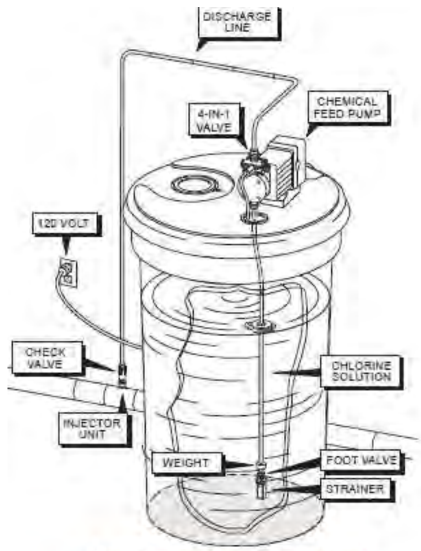
b) CHEM TECH Pump

Assembly components of Chlorination

a) EMEC V Pump Assembly Components



Components of tube well chlorination system



Typical hypochlorination feed equipment

SOPs for Chlorinator

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

WASA related info

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

Quantity of Chlorine Used

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

Dosing of Chlorine in WASA system

Periodic Maintenance for Chlorinator

Check once a month:

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

Check once a year:

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

Troubleshooting for Chlorinator

The Metering Pump gives Pulses but the additive is not injected

a.

Check Valve

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

Troubleshooting for Chlorinator

The Metering Pump gives Pulses but the additive is not injected

b.

Check Clogging of the filter

Check clogging of the filter.

Attention:

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

Check the Clogging in filter

Troubleshooting for Chlorinator

Electrical Faults for Chlorinator EMEC V Pump

1. All LEDs off, The Pump does not pulse

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

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

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

Pulse Knob, Electrical Connections

Troubleshooting for Chlorinator

Electrical Faults for Chlorinator EMEC V Pump

3. Pump Pulses are not constant

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

4. The Dosing pump gives only one pulse

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

Importance of safe potable Water

Water is essential for every one for

- Drinking
- Cooking
- Bathing
- Needed to dissolve the nutrients and be carried throughout the body
- For Sanitation purposes

WHO Drinking Water Quality Standards

Water Quality Parameters

Parameter	Existing Standard
pH at 25°C	6.5 – 8.5 pH
Colour	Not exceeding 5 Hazen units
Turbidity	Not exceeding 1.5 NTU
Conductivity	800 µS/cm
TDS	1000 mg/l
Total Hardness	100 mg/l
Free residual chlorine	0.5 - 1.5 mg/L
Calcium	75 mg/l
Odor	Unobjectionable
Total Coliforms & E.coli (no./100mL)	Absent

WHO Drinking Water Quality Standards

Water Quality Parameters

Parameter	Existing Standard
Nitrite	3 mg/l
Nitrate	50 mg/l
Magnesium	30-150 mg/l
Chloride	250 mg/l
Alkalinity	-
Carbonates	-
Bicarbonates	-
Sulfate	250 mg/l
Sodium	200 mg/l
Potassium	-

Capacity of WASA Lahore Lab for water quality Testing

Presently WASA Lahore Lab can test following water quality parameters

- Physiochemical parameters
- pH, taste , odor , color, conductivity
- TDS , Turbidity , Total hardness
- Calcium ,Magnesium ,Chloride
- Residual Chlorine , Alkalinity , Carbonates , Bi-carbonates
- Sulfate , Sodium ,potassium , Nitrite, Nitrate
- Two Microbial Parameters (total coliform, E coli)

WASA Chlorination practice

Presently WASA use Chlorination by outsourcing Sodium Hypochlorite Solution

- No SOP for chlorination is available with WASA
- 19.5 – 19.9 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*

Capacity building of WASA Lab for water quality

WASA Lahore Lab needs to improve water quality parameters for

- Provision of standard tools and equipment
- Training of operational staff
- Standardization of procedures
- Authentication of Lab through Punjab EPA
- ISO 17025 certification

Capacity building of WASA Lab for water quality

Benefits:

- Authentic source for water quality data
- Facilitate revenue generation for WASA
- Availability of trained and well equipped lab staff for national and international research and development projects
- Evaluation compliance of WHO water safety plans

Introduction to Ultra Filtration Systems

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

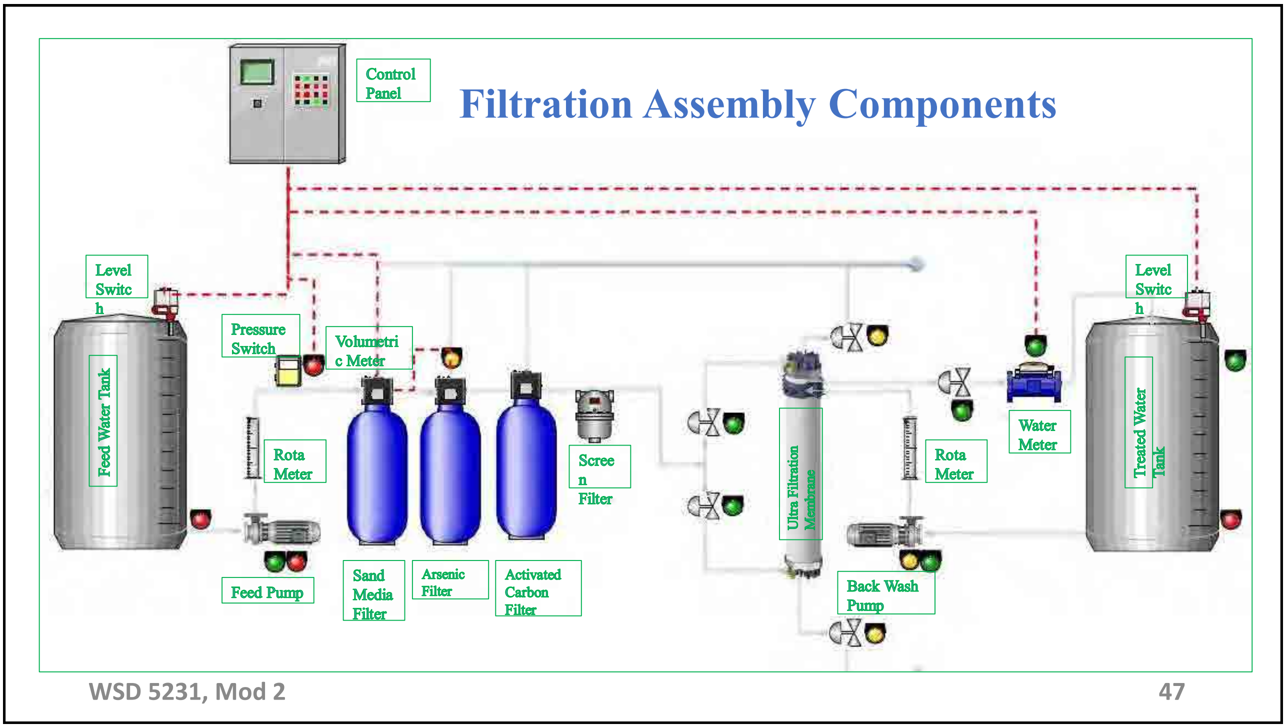
Importance of Filtration Systems.

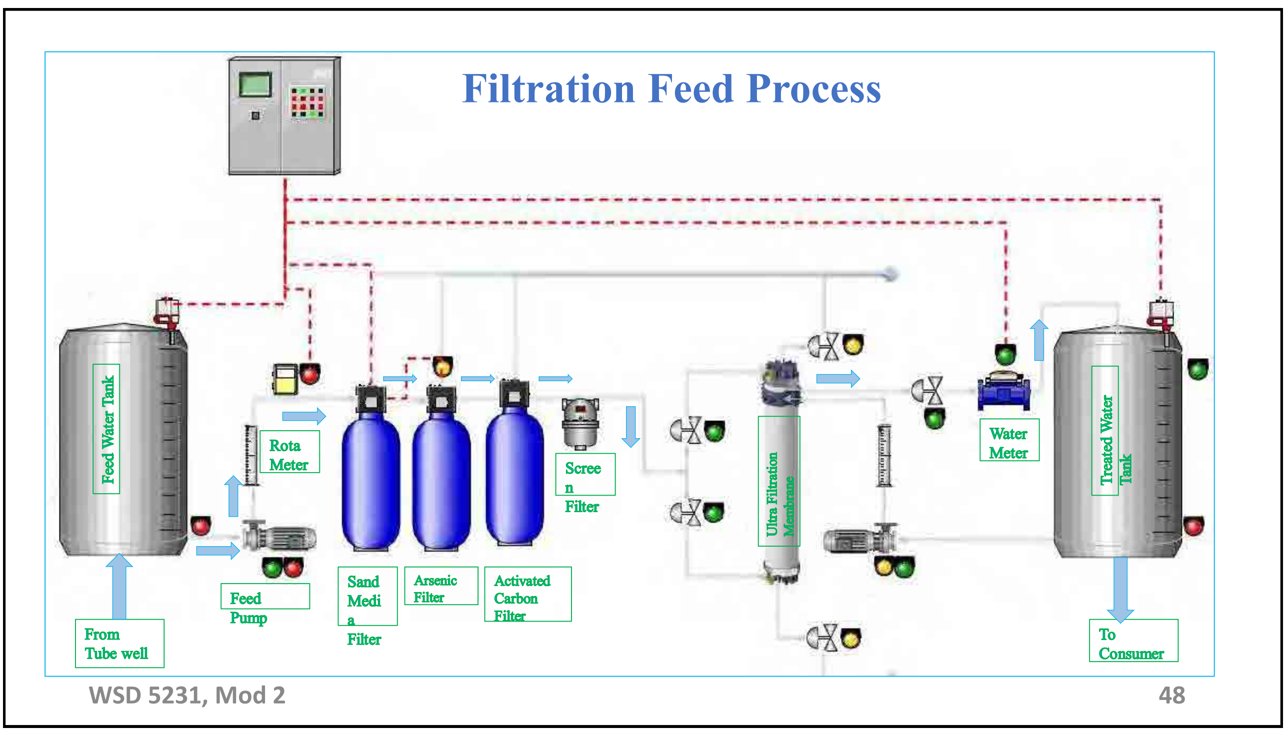
Importance of Filtration system at WASA tube well

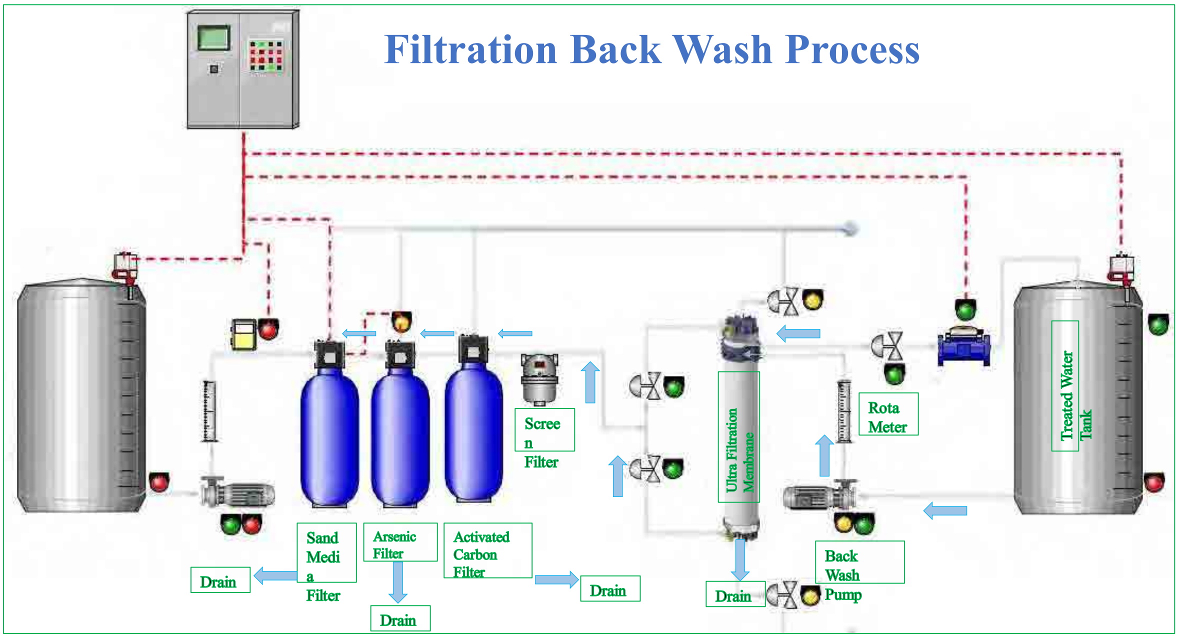
- In LDA – WASA Lahore Project the water filtration process is designed to remove pollutants which are Turbidity, Bacteria, Arsenic and heavy metals.
- Raw water will feed to Raw Water Storage Tank capacity 2,000 liter.
- Each plant has capacity of 4000 LPH.
- The water treatment process will start from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

Main components of ultra filtration systems

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


Filtration Assembly Components
Control Panel
Level Switch
Pressure Switch
Volumetric Meter
Feed Water Tank
Rota Meter
Feed Pump
Sand Media Filter
Arsenic Filter
Activated Carbon Filter
Screen Filter
Ultra Filtration Membrane
Rota Meter
Back Wash Pump
Water Meter
Level Switch
Treated Water Tank
WSD 5231, Mod 2
47


Filtration Feed Process
Feed Water Tank
Rota Meter
Feed Pump
From Tube well
Sand Media Filter
Arsenic Filter
Activated Carbon Filter
Screen Filter
Ultra Filtration Membrane
Water Meter
Treated Water Tank
To Consumer
WSD 5231, Mod 2
48



Operation of Filtration system

Pre Filtration Vessel

Function Flow Control Valve divided into 3 modes.

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

Troubleshooting of Filtration System

ULTRA-FILTRATION Troubleshooting

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

Troubleshooting of Filtration System

ULTRA-FILTRATION Troubleshooting

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

Course: ______________________________

Module: ______________________________

Training Date: ________________________

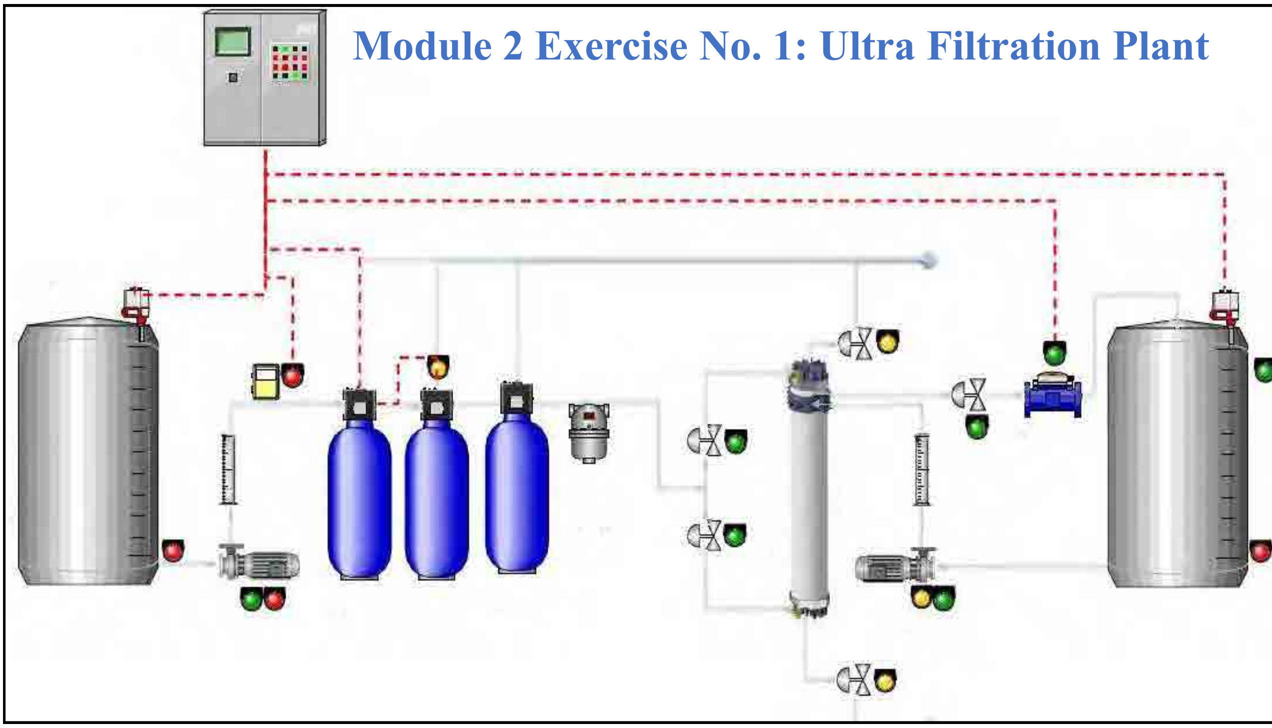
Trainee: ______________________________

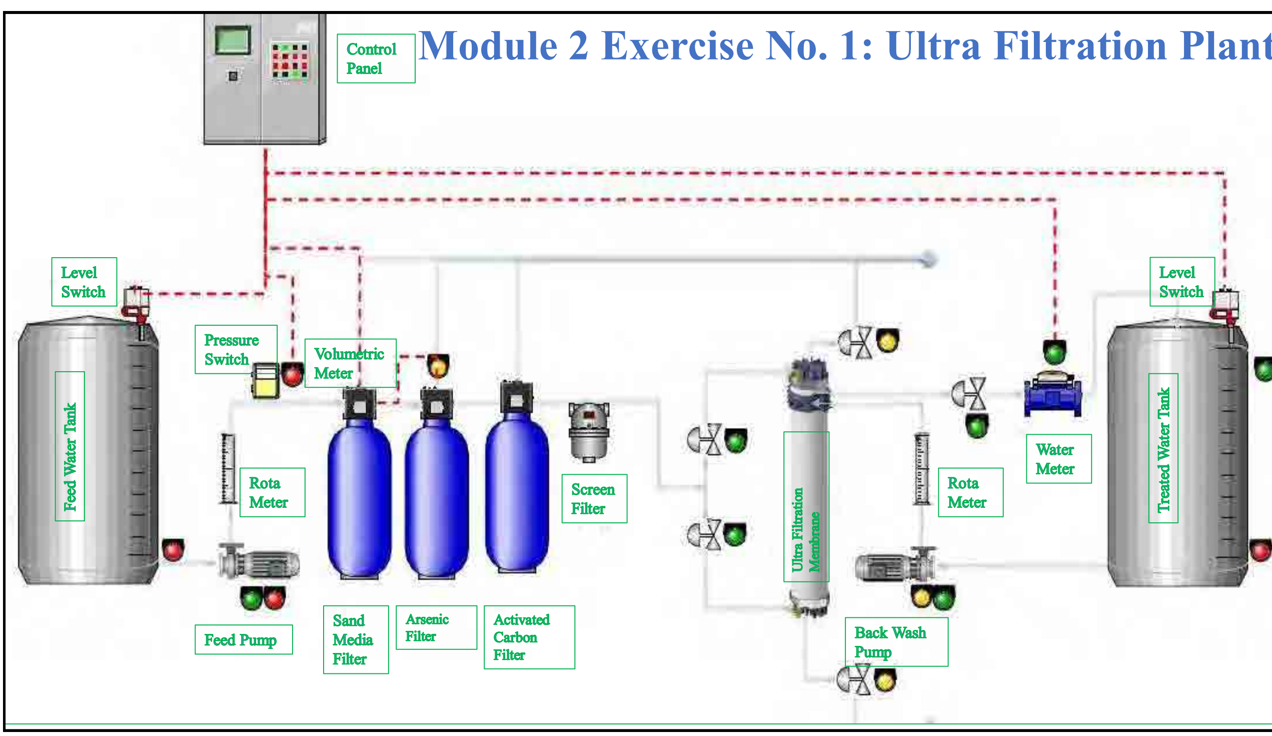
Organization: _________________________

Email: ________________________________

Contact #: _____________________________

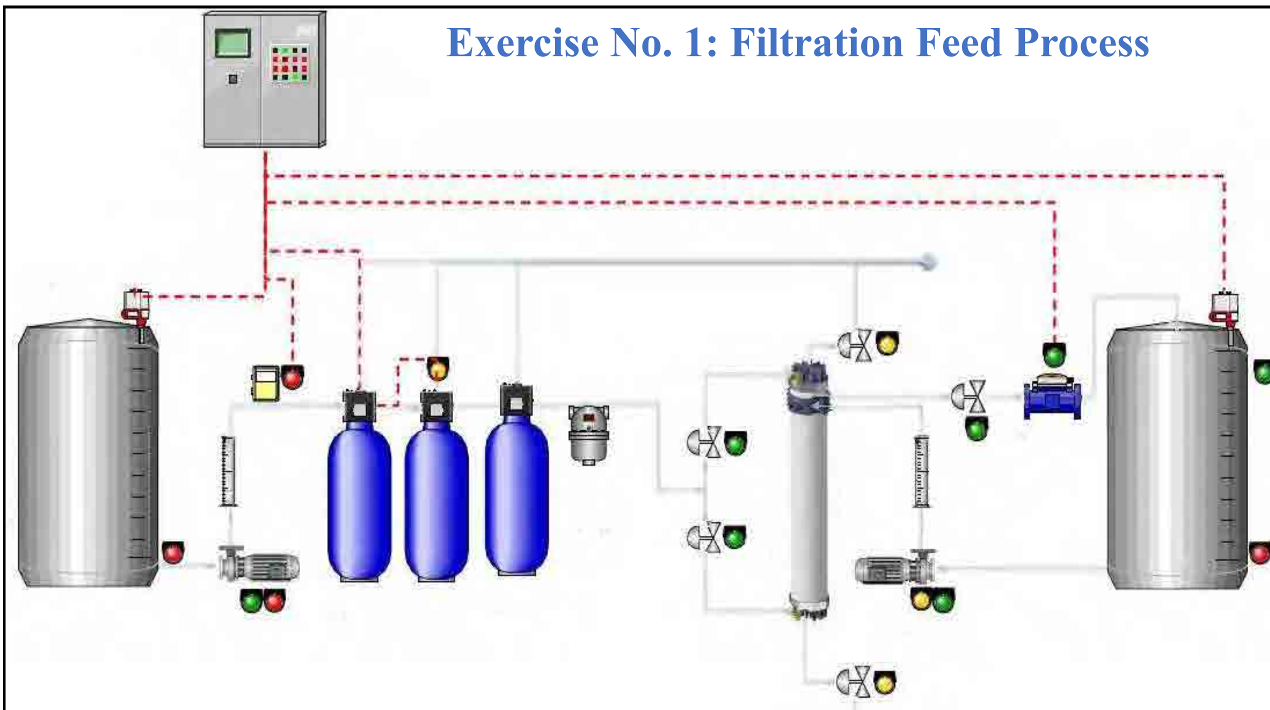
Filtration Assembly Components


Module 2 Exercise No. 1: Ultra Filtration Plant

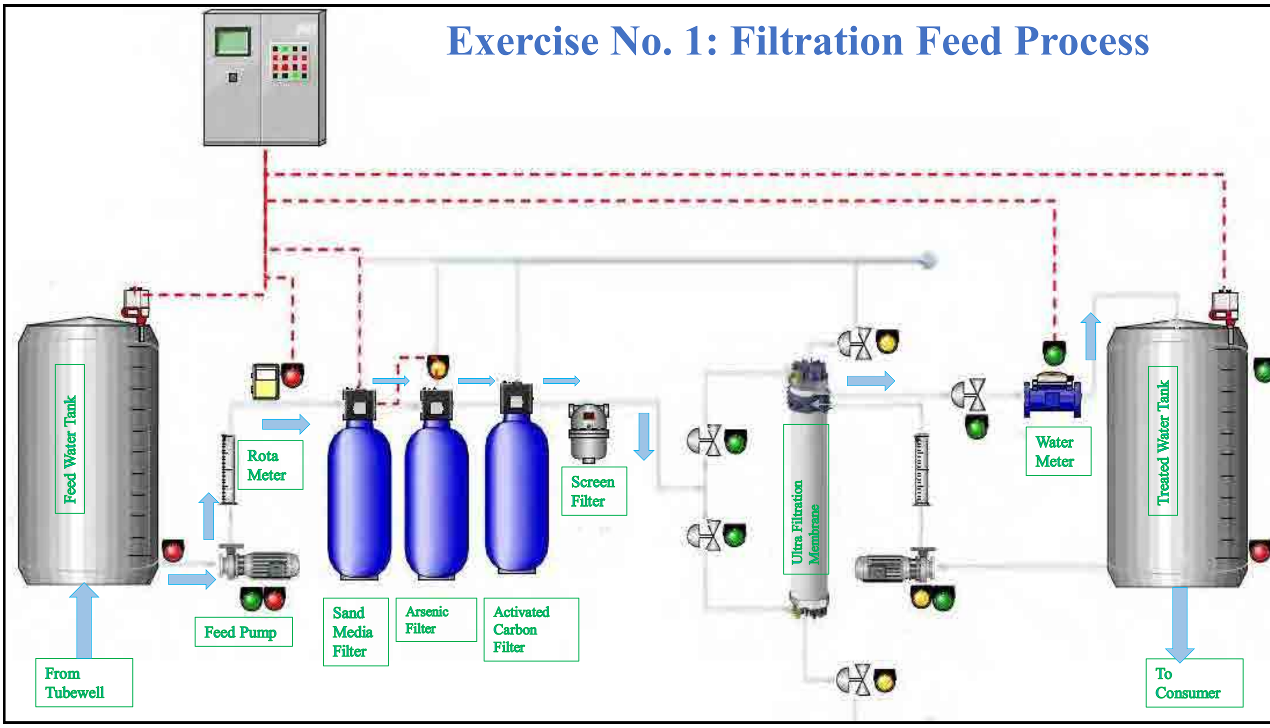

Module 2 Exercise No. 1: Ultra Filtration Plant
Control Panel
Level Switch
Feed Water Tank
Pressure Switch
Volumetric Meter
Rota Meter
Feed Pump
Sand Media Filter
Arsenic Filter
Activated Carbon Filter
Screen Filter
Ultra Filtration Membrane
Back Wash Pump
Rota Meter
Water Meter
Level Switch
Treated Water Tank

Filtration Feed Process

Exercise No. 1: Filtration Feed Process

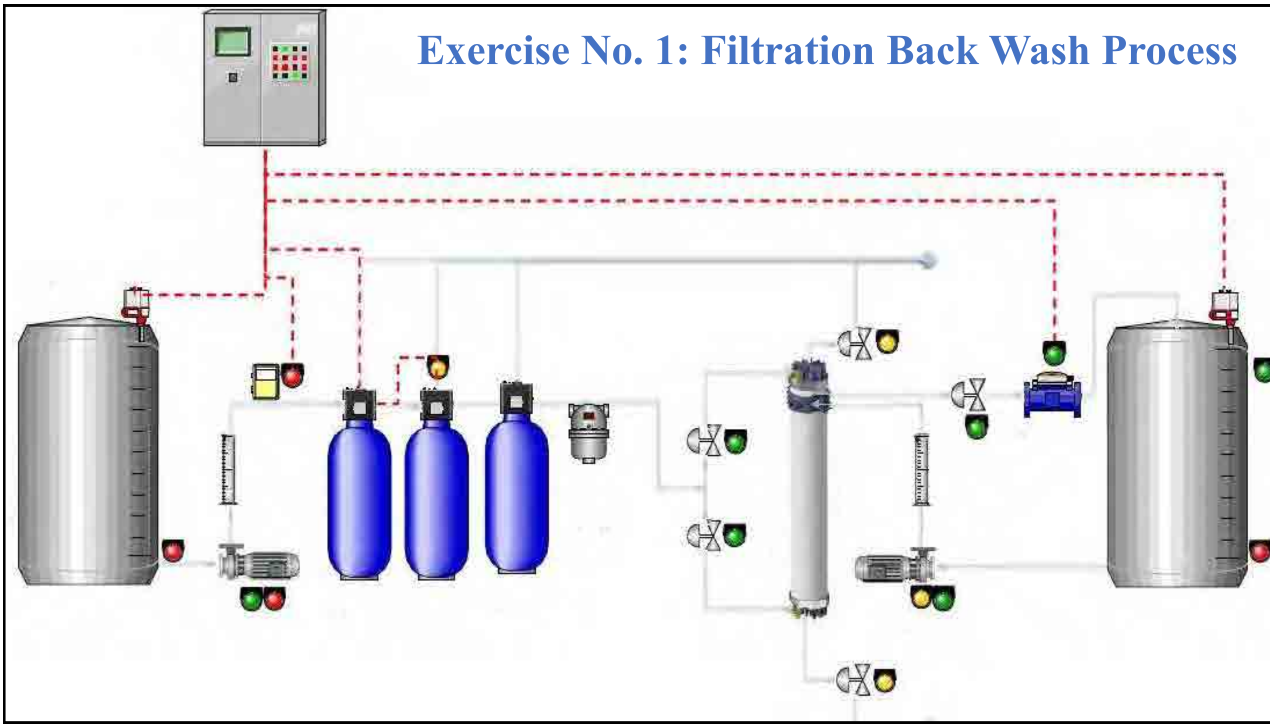


Exercise No. 1: Filtration Feed Process



Filtration Back Wash Process

Exercise No. 1: Filtration Back Wash Process



Exercise No. 1: Filtration Back Wash Process

Date:

Module 2, Exercise 2: Label chlorinator components

Participant Name:

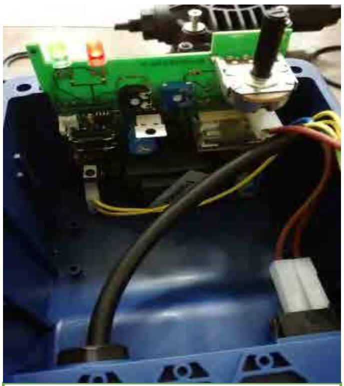
Organization:

Contact Number:

Email:

Module 2 Exercise-2

Label the Diaphragm Pump parts:



Write working principle of Diaphragm pump just in short.

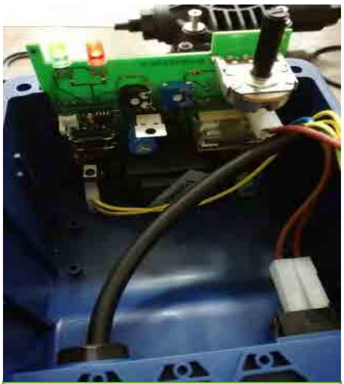
Module 2 Exercise-2:

Label the Diaphragm Pump parts:

PTFE plate

Pump Head O-Ring

Diaphragm unit



Pulse Knob, Main electrical components

Non Return Valve

Write working principle of Diaphragm pump just in short.

A diaphragm pump is a positive displacement pump that uses a combination of the reciprocating action of a rubber, thermoplastic or Teflon diaphragm and suitable valves on either side of the diaphragm (Non-Return Valve) to pump a fluid.

- Have good self-priming capabilities.
- Can handle highly viscous liquids.

Daily Operation Record (Filtration system)

Location :

Year :

Date / Month:

Approved by (Engineer)	
Prepared by (Operator)	

Facility	No.	Items	Unit	Standard/ Rated	Date										Average	Total
Filtration Plant	1	Operating Time	-		: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :		
	2	Operating Hours	hrs.													
	3	Bulk Meter	m3													
	4	Flow Meter Reading (Feed Pump)	m^3													
	5	Flow Meter Reading (Back Wash Pump)	m^3													
	6	Capacity of Raw water tank	litre													
	7	Capacity of Clean water tank	litre													
	8	Filter Pressure Reading FP1	Bar													
	9	Filter Pressure Reading FP2	Bar													
	10	Filter Pressure Reading FP3	Bar													
	11															
	12															
	13															
	14															
	15															
	16															

O & M of Mechanical Equipment
WSD 5231

Heavy Machines

Module 3

Agenda

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

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

Icebreaker and Class Introduction

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

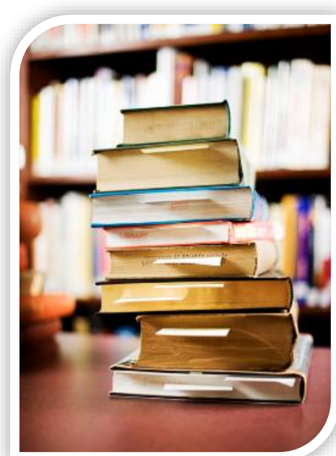
Now it is your turn…

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

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

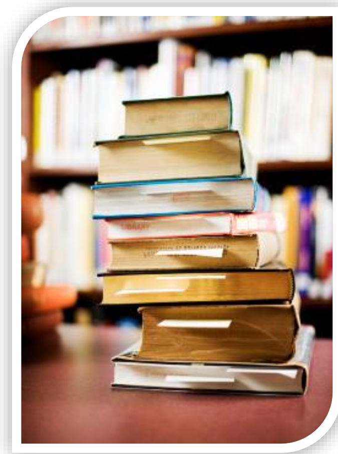
Resources and Handouts

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

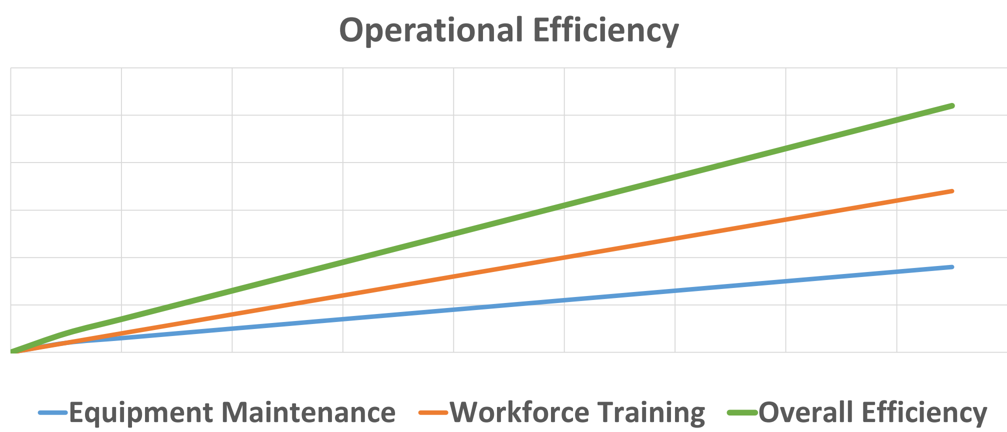


Resources and Handouts

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



Importance of Equipment and Skills



Equipment Overview

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

Importance !!!

This could be in front of my home !

Equipment Overview

How would you like to do it?

Manually or with machines ?

Equipment Overview

Velocity Cleaners (Jetting Units)

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

Equipment Overview

Velocity Cleaners (Jetting Units)

<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)

Example Specifications:

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

Equipment Overview

Vacuum Cleaners (Suction Unit)

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

Equipment Overview

Gauges and Valves

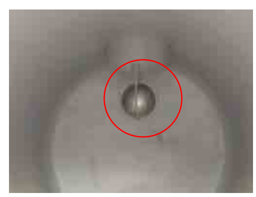
- ✓ **Gauges**: Pressure and Vacuum gauges.
- ✓ **Safety Valves**:
  - ✓ auto safety valve for the vacuum pump to avoid over loading
  - ✓ auto safety valve for the pressure pump to avoid over loading



Equipment Overview

Gauges and Valves

- ✓ **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.

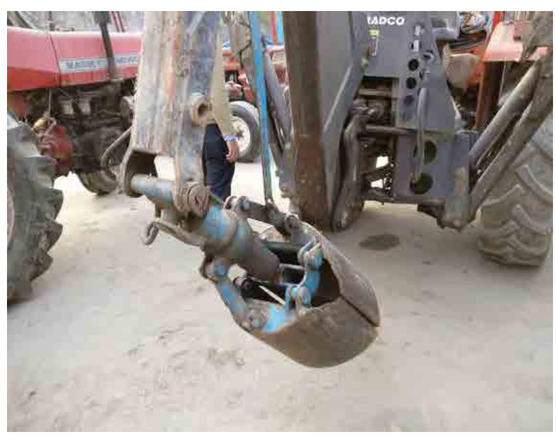
✓It can be used as an excavator and as a loader.

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

Equipment Overview

WASA Backhoe

Koyker Backhoe with regular bucket

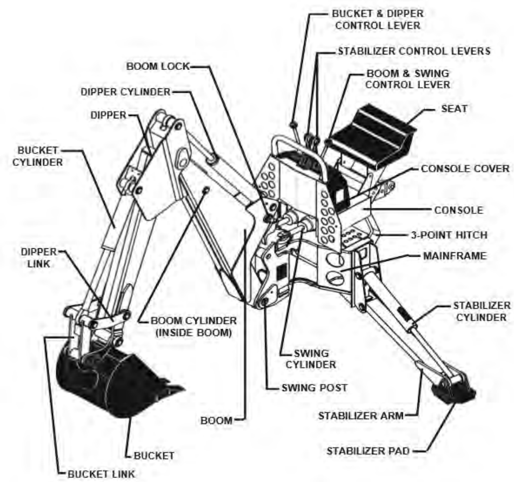


Bradco Backhoe with clamshell bucket (customised)

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

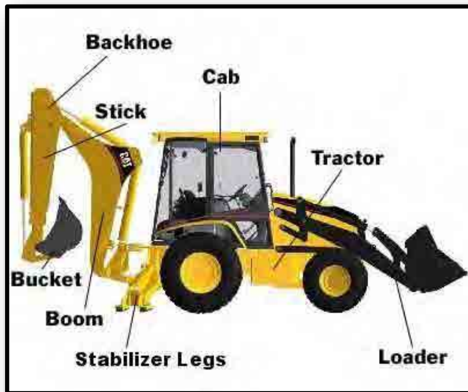
WASA Backhoe (Koyker, KB85)

- ✓**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

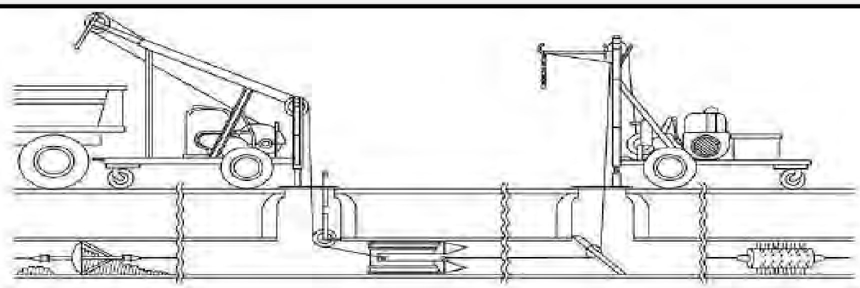
Water Tanker

- ✓ 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

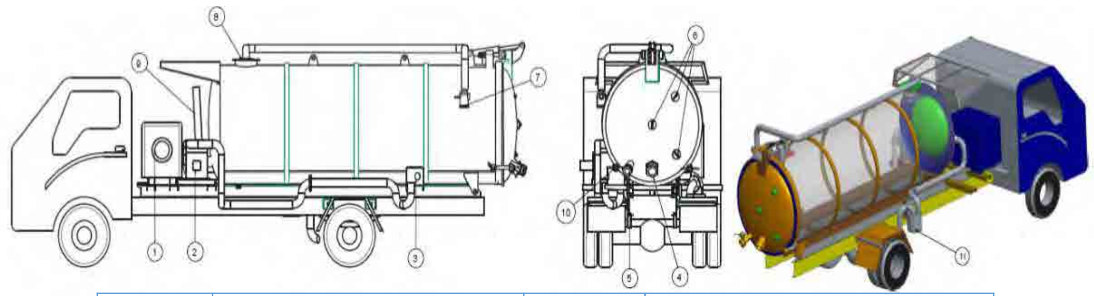
Vehicle Specification: Isuzu N-Series (courtesy RAVI Motors, Lahore)			
DIMENSION & WEIGHTS (Chassis only)		Short Wheel Base (SWB)	Long Wheel Base (LWB)
Wheel Base (WB)	mm	2460	3360
Overall Length (OAL)	mm	4610	5830
Overall Width (OW)	mm	1695	1695
Overall Height (OH)	mm	2120	2120
Tread Front (AW)	mm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

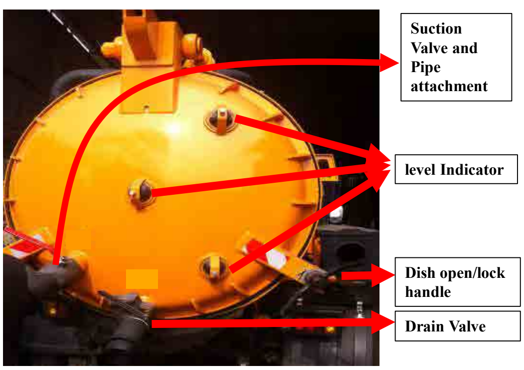
Main Assembly Component, **Suction Unit**

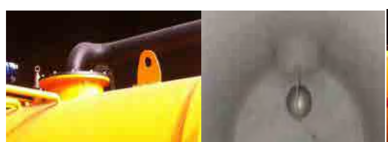


Parts No.	Description	Parts No.	Description
1	Auxiliary Engine	7	Secondary cutoff Protection
2	Vacuum Pump	8	Primary Cutoff Protection
3	Filter	9	Telescopic/Hydraulic Jack
4	Drain Valve	10	Dish Open/Lock Handle
5	Suction Valve	11	Silencer air exhaust from pump
6	Level Indicators	12	

WSD 5231, Mod. 3 39

Main Assembly Component, **Suction Unit**



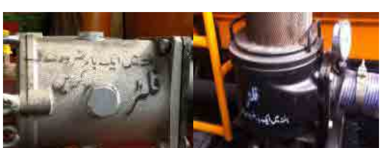


Primary CUTTOFF Protection

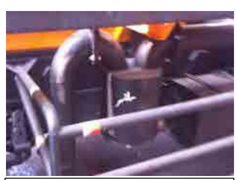
Secondary CUTTOFF Protection

Auxiliary Engine or Prime Mover

Vacuum Pump



Vacuum Pump Air intake Filter

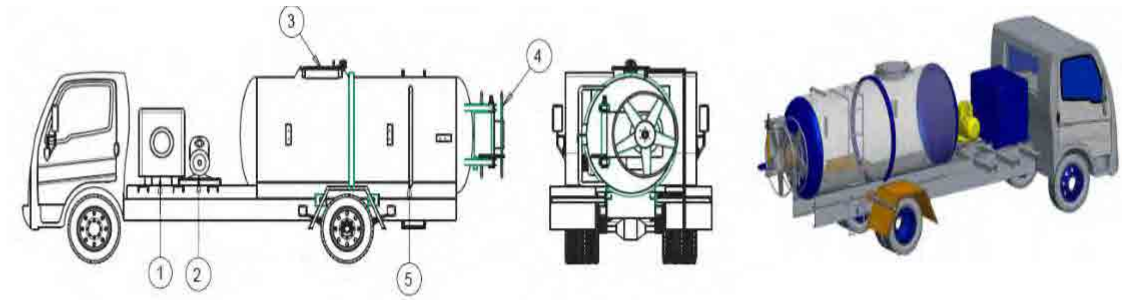


Air outlet Silencer

Hydraulic Jack

WSD 5231, Mod. 3 40

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

WSD 5231, Mod. 3

41

Main Assembly Component, **Jetting Unit**

Engine

High Pressure jetting Pump

Y Strainer

Manhole

Jetting Real

WSD 5231, Mod. 3

42

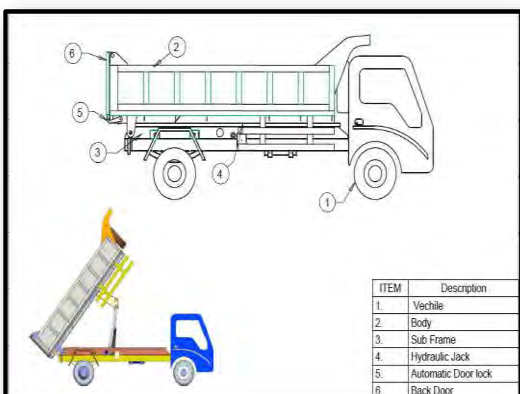
Main Assembly Component

Combined Jetting and Suction Unit

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

Main Assembly Component

Dump Truck



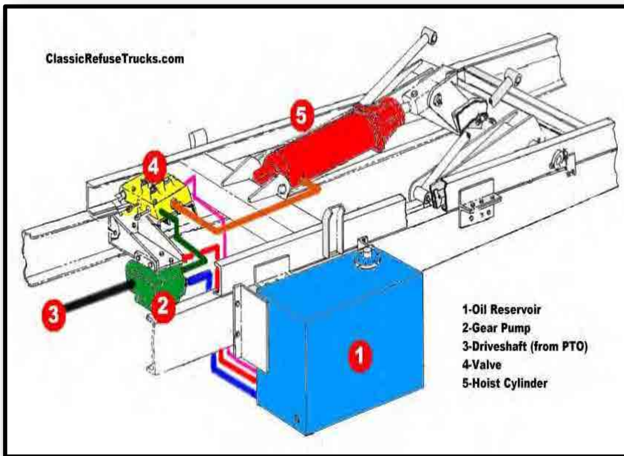
Dump Truck Components

Dump Truck (courtesy Kisaan Engineering)

Main Assembly Component

Load Capacity

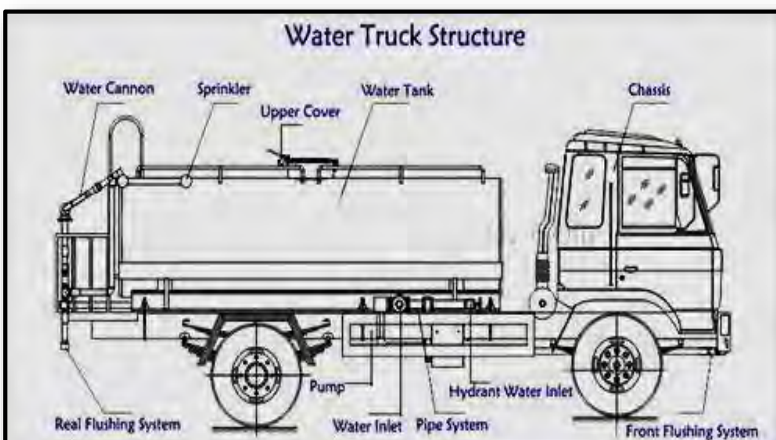
- ✓ 4 Ton or 3.3 cubic yards of dirt
- ✓ Average commercial dump truck holds anywhere from **10 to 14 cubic yards** of dirt.
- ✓ The Dump Trucks used at local service facilities are much smaller with a capacity of 5 to 10 cubic yards of dirt.



Dump Truck (courtesy Kisan Engineering)

Main Assembly Component

Water Trucks



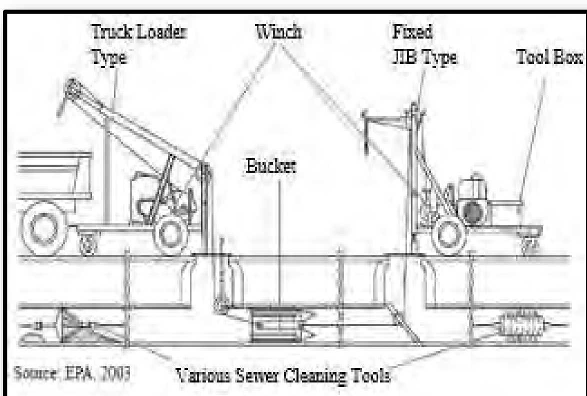
Water Tanker Components

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		●	●		●

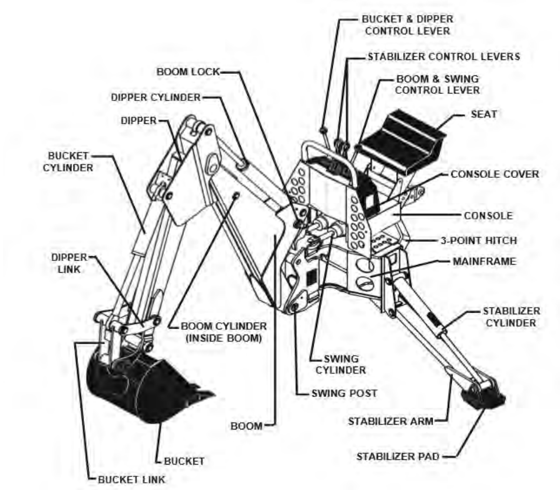
● = Most effective solution for a particular problem

• = 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

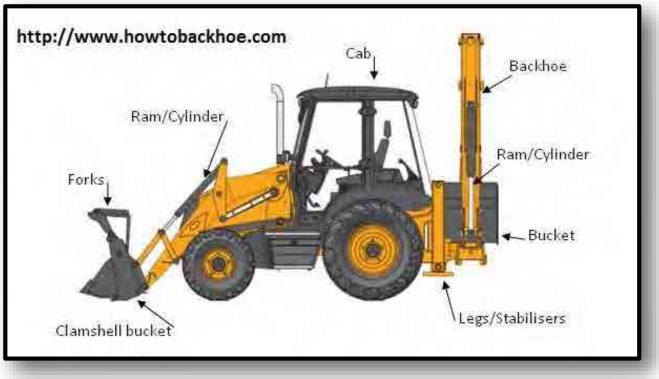
✓**Superstructure:**
- a. The main frame work of the equipment structure
- b. Also contains:
  - i. Power source (i.e., engine compartment)
  - ii. Main hydraulic pump and various hydraulic valves
  - iii. Cab house operator's compartment and controls

✓**Undercarriage:**
- i. Axles front and rear
- ii. Drive train

Main Assembly Component

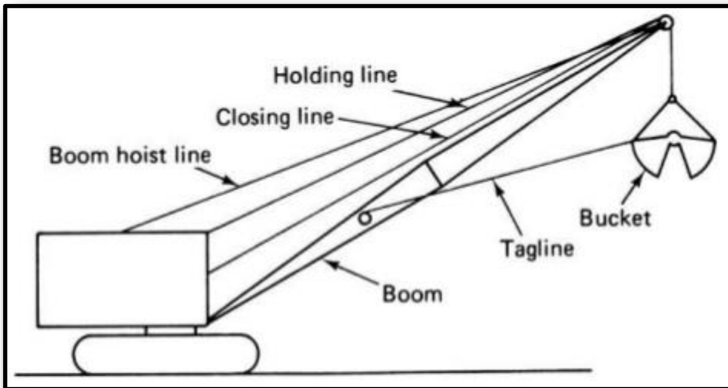
✓**Front end attachments**
- i. Bucket standard or four-in-one clam

✓**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.

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 <u>each</u> 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

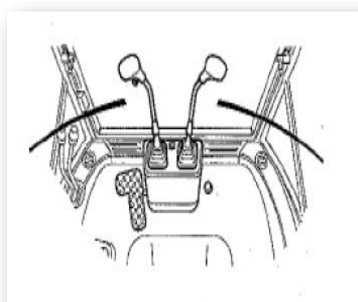
19.Levers

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 <u>air filters</u> 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, <u>not too tight or too loose</u>
- ✓Inspecting and changing brake pads
- ✓Inspecting and replacing tires

Lubrication Oil, your Machines's lifeline

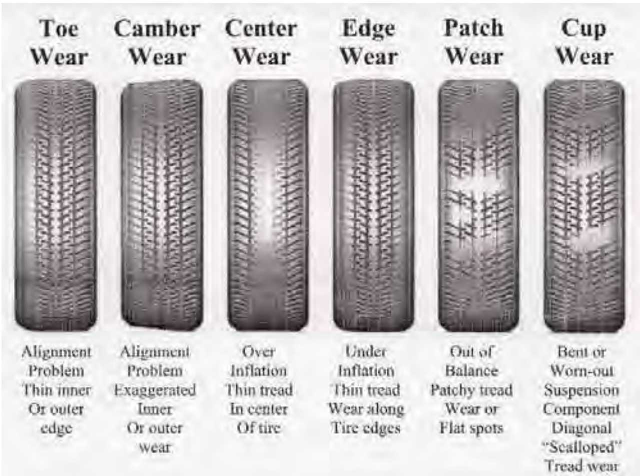
- The most important issue in your equipment's life is selecting the correct oil and changing it regularly.

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**

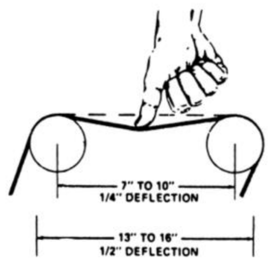
Belts drive your operations !

Worn-out belts

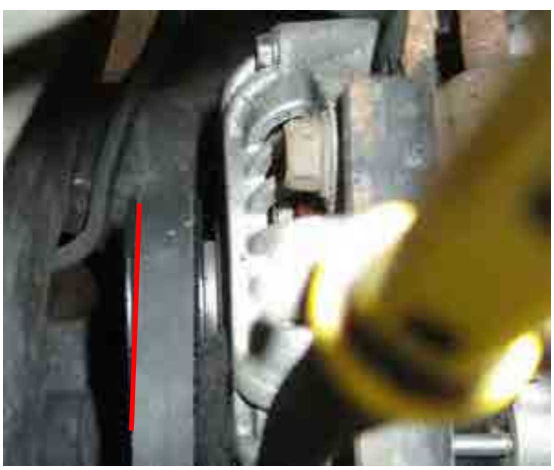
Always buy correct type!

Drive belt tension adjustment

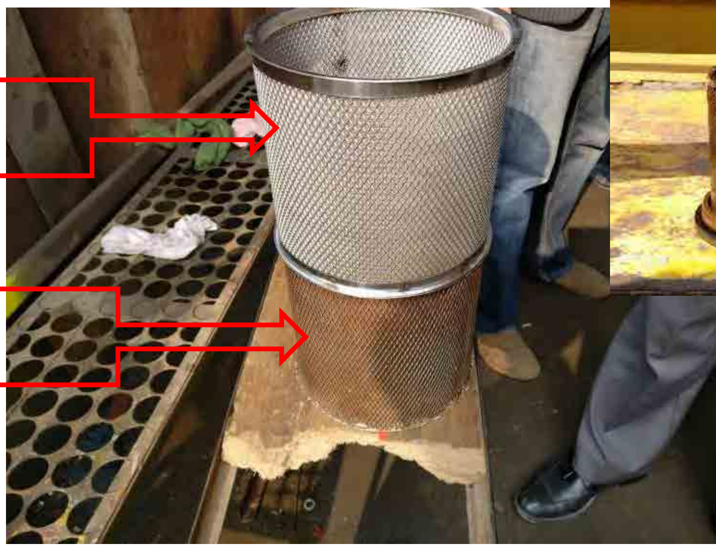
Fig. 1: A gauge is recommended, but you can check belt tension with thumb pressure



Belt alignment



Filters are lungs for your machines!



Lessons from OJT

Lessons from OJT

WSD 5231, Mod. 3

167

Lessons from OJT

WSD 5231, Mod. 3

168

Lessons from OJT

Steel Lower Manhole Guide Shoe

Lower Manhole Hose Guide Roller-Grabber

WSD 5231, Mod. 3

169

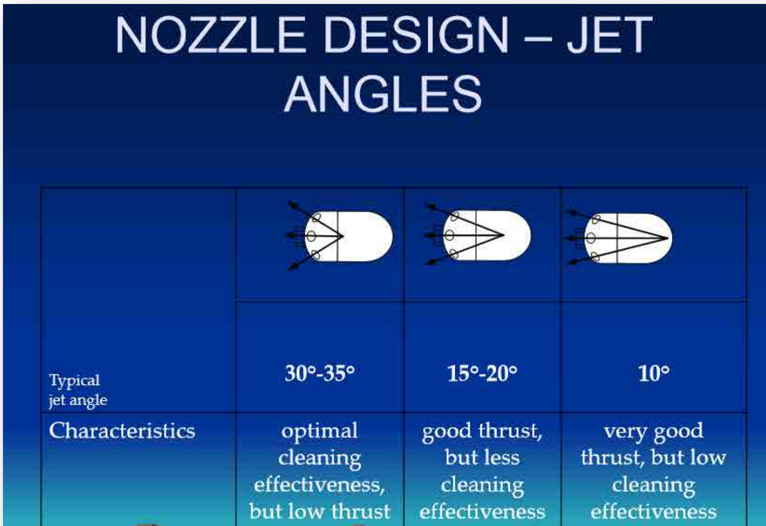
Lessons from OJT

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

WSD 5231, Mod. 3

170

Lessons from OJT



Wrap-up

Things to take home…

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

Operations and Maintenance of Mechanical Equipment

Application of 5S

Quality Tool for Operational Excellence

Objectives of Application of 5S

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

- Productivity
- Efficiency
- Quality
- Safety

3/30

jica ALJAZARI ACADEMY

What is 5S?

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

4/22

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

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

1. Sort (Seiri)

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

1. Sort (Seiri) For wavering items

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

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

7/22

2. Set-in-order (Seiton)

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

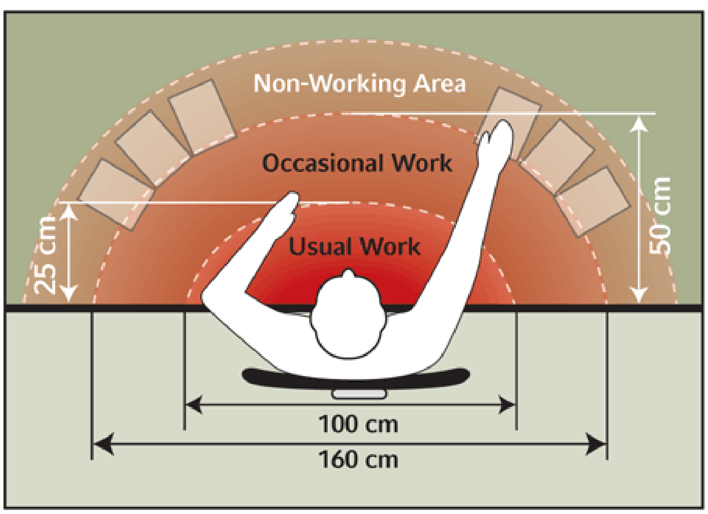
8/22

3. Shine (Seiso)

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

9/22

Ease of Reach and Operation



10/22

4. Standardize (Seiketsu)

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

5. Sustain (Shitsuke)

- It involves developing habits to implement the 5S philosophy on an ongoing basis.
- It is a housekeeping, standardization and process optimization program/tool.
- **5S activity is conducted systematically and regularly.**
- **5S activity is tracked through a visual control board.**

Before

After

WASA Outfall Workshop, Lahore

Before

After

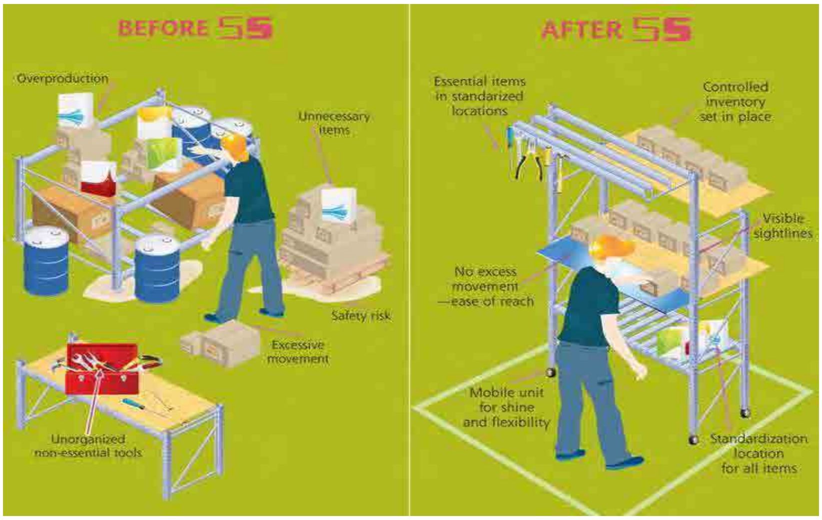
WASA South Yard, Lahore

Before

After

SCBA equipment was buried under this

15/25

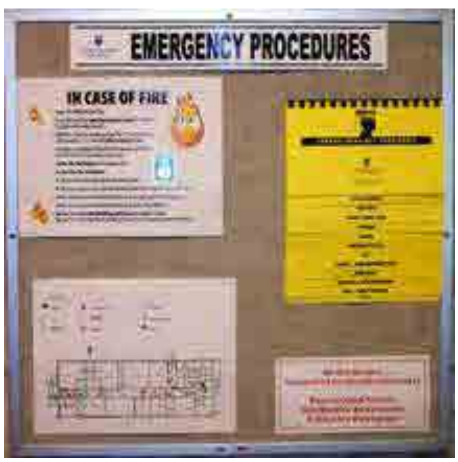


16/25

5S is a continuous improvement tool !!!

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

17/25



Emergency Procedures

18/25

Emergency Contact List

19/25

1

Health, Safety & Environment for Operations and Maintenance of Mechanical Equipment

HSE Trainer : IHSAN UL HAQUE JAVED

2

Activities for On-the-Job Training

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

- HSE: Importance & Policy
- Mechanical Hazards
- Hazard Hunting & Job Safety Analysis
- Fire Fighting & Warning Signs
- First Aid box & Spine Board
- CPR Demonstration

3

Health, Safety & Environment

Discipline that specifically studies and develops guidelines to implement:

- Health of workers and public
- Safe working conditions related to operation & maintenance
- Environmental protection

Importance of HSE Policy and its implementation

A top level governing HSE regulation to ensure worker and public health, safety and environmental protection

4

Draft HSE Policy

We are committed to providing a safe working environment, where safety and health are part and parcel into every operations, based on the doctrine that every accident and occupational illness is preventable.

Affectees of adverse environmental conditions:

- All employees
- Contractors
- Who work on the behalf of WASA
- Visitors
- Suppliers
- General public

5

Identification of Hazards

What is Hazard?

Hazard is a risk to Health, Safety, Property or Environment.

Types of Hazard

Physical
- Fall
- Slip
- Trip
- Confined space

Mechanical
- Equipment
- Pressure
- Noise &vibrations
- Pinch
- Cut
- Pull in

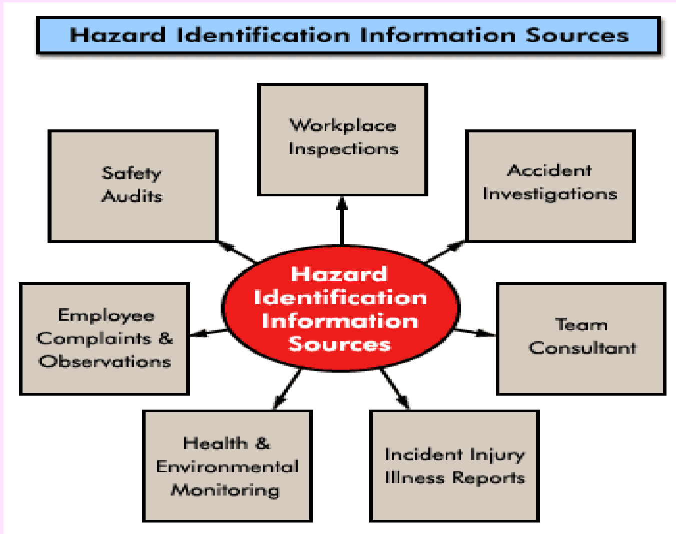
Chemical
- Sewerage or wastewater
- Gas emissions
- Toxic material

Biological
- Bacteria
- Virus
- Pathogens

Psychological
- Stress
- Ergonomics
- Exertions

6

Identification of Hazards



7

Hazards related to Pumps

Confined Space

Corrosion & Contamination Leakage (slip and fall)

Pinch, Cut, Wrap

Noise & Vibration

8

Hazards of Induction Motor

Missing Top Cover, Cut Hazard,
Tool Lost and Material Damage Hazard

Poor housekeeping

Broken Casing

9

Hazards of Valves

Corrosion and
Contamination

Ergonomics

10

Hazards of chlorination & filtration system

Dust and Spider webs

Chemical hazard

Leakage hazard

11

Hazards of Heavy Machine

Corrosion &deterioration

Noxious emissions

Oil leakage

Broken door &
No seat belt

12

Hazards & Related Risks

Pump

1. Confined space: Sudden pressure release, fire, suffocation
2. Missing warning and safety signs: No identification of suitable PPE
3. Slip & Fall: Injury, hospitalization
4. Noise and vibration: Stress, psychological disorder
5. Cut, crush, pinch: Physical injury
6. Corrosion and contamination: Illness and environmental degradation
7. Defective Personal protective equipment: Accident and injury

13

Hazards & Related Risks

Valves

1. Confined space: Injury, Suffocation, poor illumination
2. Ergonomics: Backache, muscular injury, sprain
3. Access to operating nut: Strain, backache, tendon problem
4. Slip & Fall: Injury and hospitalization
5. Defective hand and power tool: Cut, crush, pinch
6. Corrosion & contamination: Equipment deterioration Illness, environmental degradation

14

Hazards & Related Risks

Chlorination & Filtration System

1. Loose electrical connection: Spark and electric fire
2. Chemical hazard: Illness, rashes and ophthalmic disorder
3. Slip and fall: Injury and hospitalization
4. Leakage or blockage: Environmental degradation and Equipment damage
5. Bursting of pipe: Environmental degradation and loss of property

15

Hazards & Related Risks

Heavy Machines

1. Physical condition of the operator or driver: Accident
2. Radiator, fan belt effects: Machinery spoilage
3. Musculoskeletal injury: Strain, sprain, lost time injury
4. Opaque vision due to fog or mist: Accident, machinery damage
5. Working close to confined space: Accident, machinery damage
6. Working on loose soil areas: Fatal accident, machinery damage
7. Release of high pressure: Fatal accident, injury, hospitalization
8. Working with heavy loads: Accident and machinery damage
9. Poor/No traffic management: Fatal accident
10. Heat, cold, hunger, mental stress : Fatal accident
11. Cellphone: Fatal accident
12. Noxious emissions: Environmental degradation and source of illness
13. Improper or defective PPE: Injury and hospitalization
14. Not using PPE: Injury and hospitalization
15. Carefree attitude: Accident and death

16

Major outcomes of Hazards

Cut & Pull in

Amputation

Reddening of eye

Ergonomics

Noise & Vibration

Skin rashes

17

Major outcomes of Hazards

Fall and Death

Fall and Death

18

Major outcomes of Hazards

Pinch, cut, strike

Accident due to vision obstruction / frequent movement

19

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

20

Hazard Hunting

Regular inspections for O & M jobs and identification of hazards by the facility staff and reported to facility supervisor or in charge is continuous process to mitigate the hazard . After collection of data, facility in-charge may 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

21

Hazard Control During Operations & Maintenance

More Effective

1. **Elimination** : Remove unsafe conditions (abandon unsafe Machinery)
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

22

Job Safety Analysis (JSA)

Job safety analysis (JSA) helps integrate accepted safety, health 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 particular job, in terms of priority rating and the hazard coding.

23

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.**

24

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

25

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

Priority Level of Hazard = Probability x Severity

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

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

26

Job Safety Analysis (JSA) Example - 01

Location:	HEAVY MACHINE STOCK YARD									
Date:	November 20th, 2017									
Conducted By:	SDO and Operations Staff									
Sr. #	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	Sewer man or Operator	27th Nov 17	27th Nov 17	Done
2	Seat belts worn out on Backhoe 2	Injury (head and torso)	3	4	12 (H)	Replace seat belts	Driver or Operator	28th Nov 17	Done	Seat belts ordered
3	Oil pan leaking on Water Truck 5	Slip and Environment	2	3	6 (M)	Repair oil pan seal	Driver or Operator	30th Nov 17	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.

27

Firefighting

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

28

Firefighting

If Fire extinguisher containing carbon dioxide or dry Chemical powder 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 dry sand may be kept in a polythene bags

29

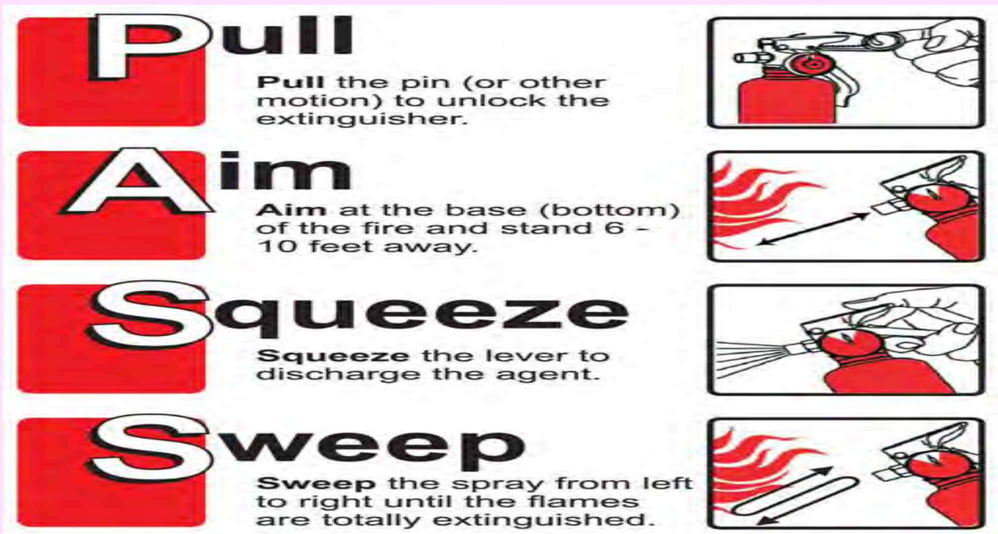
Emergency Response

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

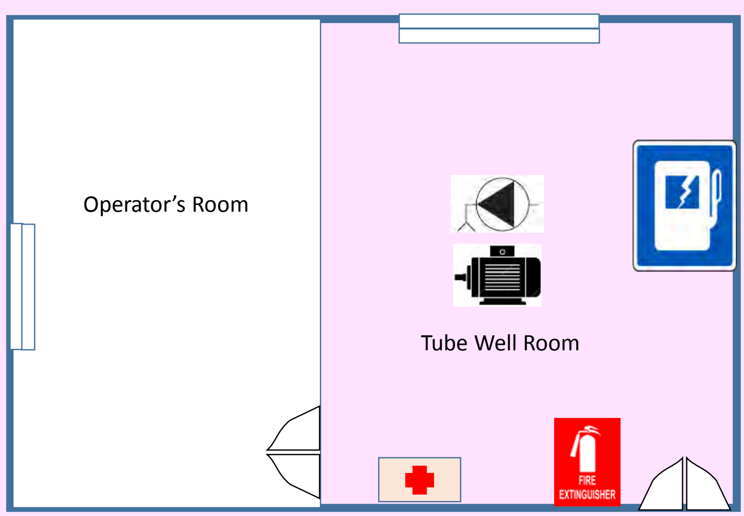
30

Steps of using fire Extinguisher



31

Location of Fire Extinguisher & First Aid Box



32

First Aid Guidelines

1. Provision of first aid kit & formation of first aid team at workplace is essential.
2. For minor problem first aid kit may be helpful.
3. For major accident rescue 1122 may be called.
4. WASA facility in charge should constitute a first aid team for operation and maintenance related accidents or incidents.

First Aid Team

The first aid team should comprise of trained:

- First Aider
- A rescuers
- A helpers

33

First Aid Box & Spine Board

Accessories

- Panadol tab
- Dichloron tab
- Sterile gauze pads
- Adhesive tape
- Sterile bandage
- Splints
- Antiseptic wipes
- Antibiotic ointment
- Antiseptic solution
- Tweezers
- Sharp scissors
- Safety pins
- Thermometer
- Eye wash Solution

34

Spine Board Demonstration

35

First aid measures for chlorine

1) Inhalation Safety:

1. Wear Safety mask
2. Move victim to fresh air. Keeping chin upward
3. Keep victim in a position comfortable for breathing
4. For poor breathing administer oxygen by CPR
5. Pinch the nose of victim before giving oxygen
6. DO NOT allow victim to move about unnecessarily
7. Immediately call RESCUE 1122

36

First aid measures for chlorine

2) Skin Contact Safety:

1. Flush with water for 5 minutes.
2. If irritation or pain persists, see a doctor.
3. Quickly remove victim from source
4. DO NOT attempt to rewarm the affected area on site
5. DO NOT rub area or apply direct heat
6. Gently remove clothing etc for better air circulation
7. Remove rest of the garments ,if required
8. Loosely cover the affected area with a sterile dressing
9. DO NOT allow victim to smoke
10. Immediately call RESCUE 1122

3) Eye Contact:

1. Flush contaminated eye(s) with flowing water for 5 minutes
2. Keeping the eyelid(s) open
3. If irritation or pain persists, see a doctor
4. Avoid direct contact
5. Wear chemical protective gloves
6. DO NOT attempt to rewarm
7. Cover both eyes with a sterile dressing
8. Immediately call RESCUE 1122

37

What is CPR?

- A sequence of techniques used to sustain life in the absence of spontaneous breathing and heart beat
- Chest compressions and rescue breath are called cardiopulmonary resuscitation
- Objective is to maintain victim's breathing and circulation until emergency aid arrives.

Important steps for CPR

Check
Call
&
Care

38

Check, Call & Care

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

Follow guidelines:

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

39

Is person responsive?

Check the victim for a response

If no response

CALL Rescue 1122

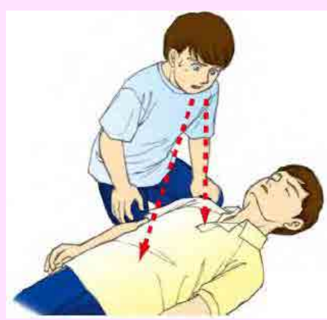
40

Open the airway &
Maintain the airway open

Head tilt and chin lift

41

Check for breathing



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

42

If no signs of life are present

Start Chest Compression

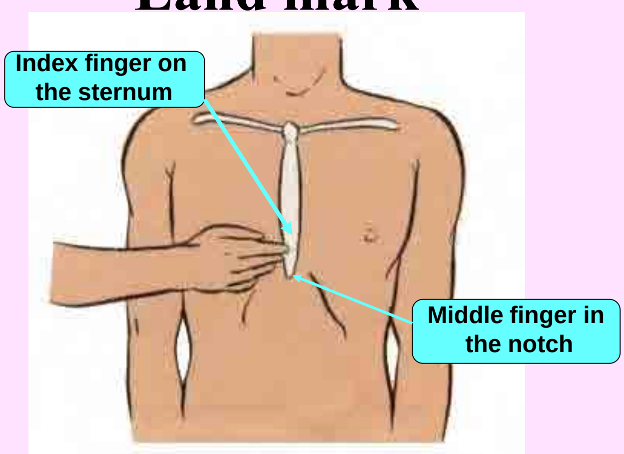
20/2

push hard and push fast

Continue for 2 minutes
100 to 120 total compressions

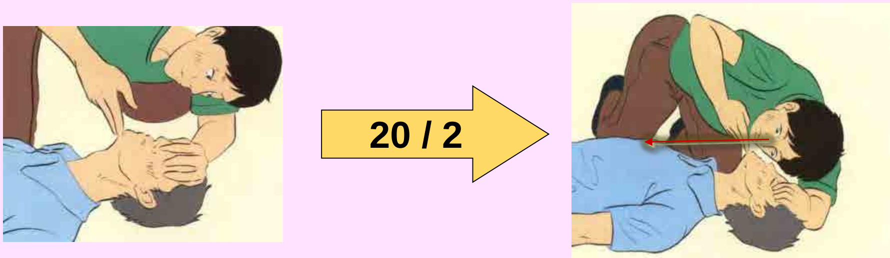
43

Land mark



- Place the heel of on the center of the victim’s chest
- Place the heel of your other hand on top of the first hand
- Press down on the sternum 1 ½ to 2 inches

44



- ✓ After 20 compressions open the airway again using head tilt and chin lift give two breaths while watching the chest rise
- ✓ Rescue Breaths should last for 1 second.

45

ABC’S OR CAB’S???

Change in CPR guidelines: no more ABC’s but rather…CAB’s

C= Circulation

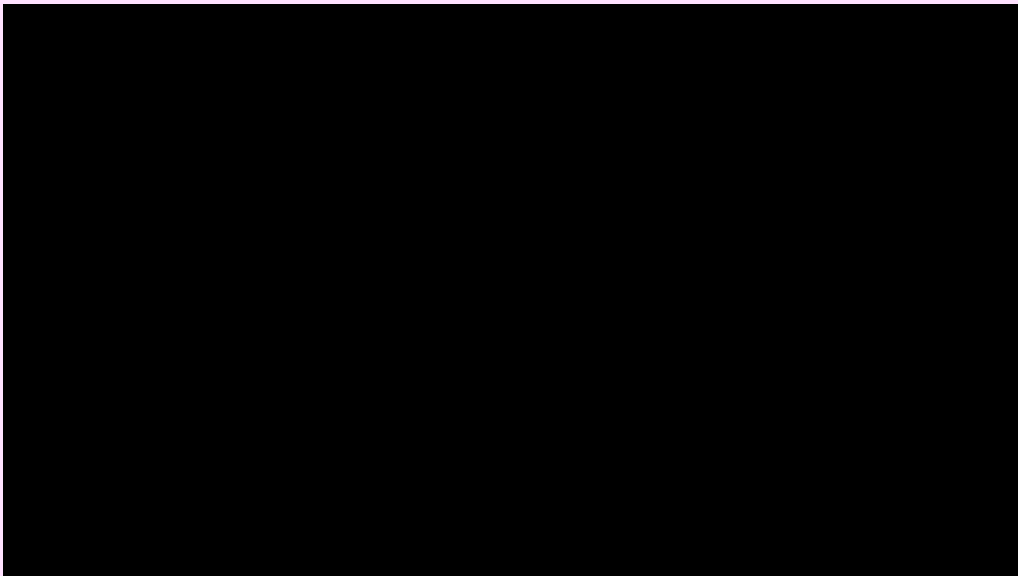
A= Airway

B= Breathing

The CAB’s are your priority management steps to life-saving

46

CPR Demonstration



47

Handling of Manikin

- For handling and demonstration purpose wear rubber gloves
- For demonstration at site use spare nylon sheet as underlay
- In case of more number of trainees separate mouth protector be provided.

Cleaning of Manikin

- Use Soap and water for dirty materials swiping gently
- Cleaners containing wax, oil or citrus are not recommended
- The face skin may also be sanitized with alcohol wipes or soaked in a solution of ¼ cup bleach mixed with one gallon of water for 10 minutes

Storage of Manikin

- Always store and transport the manikin in nylon carry bag
- Store the manikin in a cool dry area at temperature between 50-70 °F and 50% relative humidity
- For storage longer than one month, the batteries should be removed from the CPR rate monitor
- The manikin head should be removed for the protection of the facial features, specifically the nose

48

Contact Information

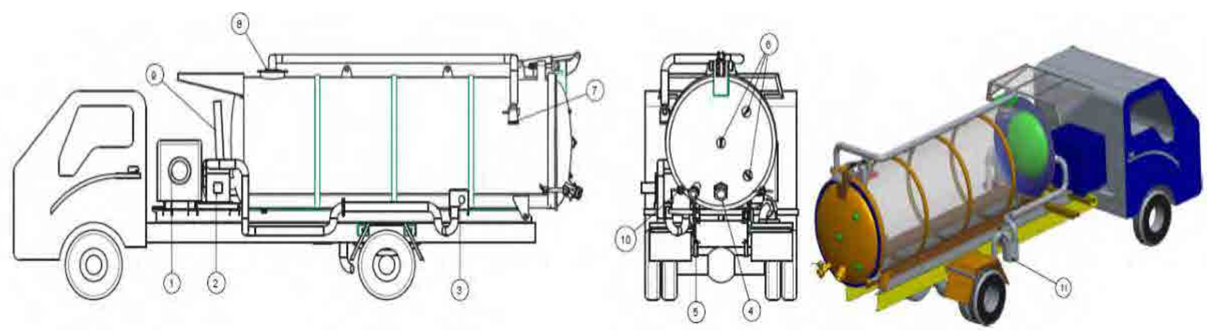
Faculty Names	
JICA Expert Kudo Ryuta (Mechanical)	
Course Leader Mubasher Ahmad Cheema	
Sr. Instructor (HSE) Ihsan-ul-haque Javed	
Sr. Instructor (Electrical) Jawad Shahid	
Young Professional Tanveer Shahzad	

49

MODULE 3, EXERCISE NO. 1:

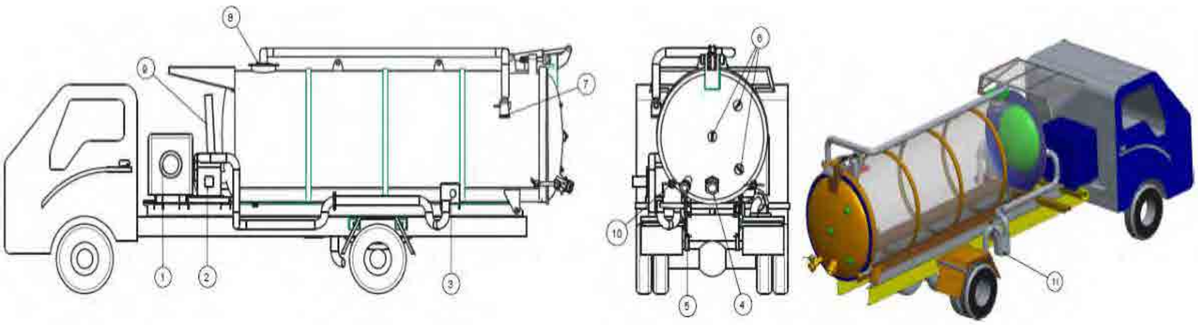
ASSEMBLY COMPONENTS OF SUCKER AND JETTER MACHINE

EXERCISE NO. 1: ASSEMBLY PARTS OF SUCKER MACHINE



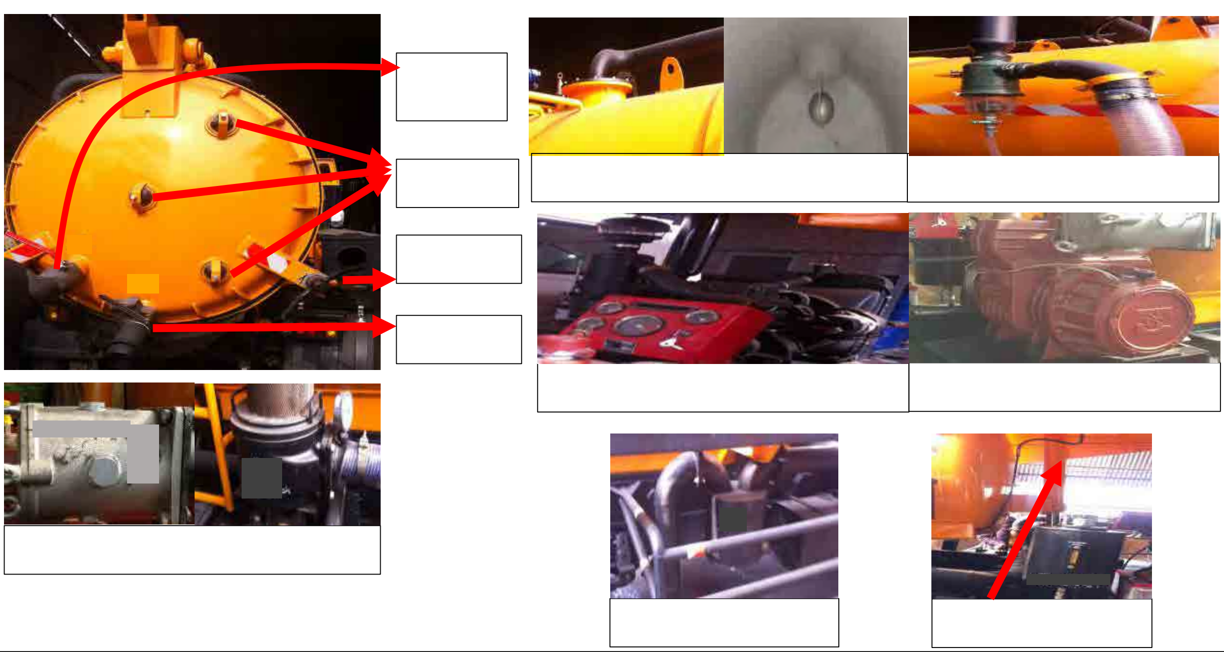
Parts No.	Description	Parts No.	Description
1		7	
2		8	
3		9	
4		10	
5		11	
6		12	

EXERCISE NO. 1: ASSEMBLY PARTS OF SUCTION MACHINE

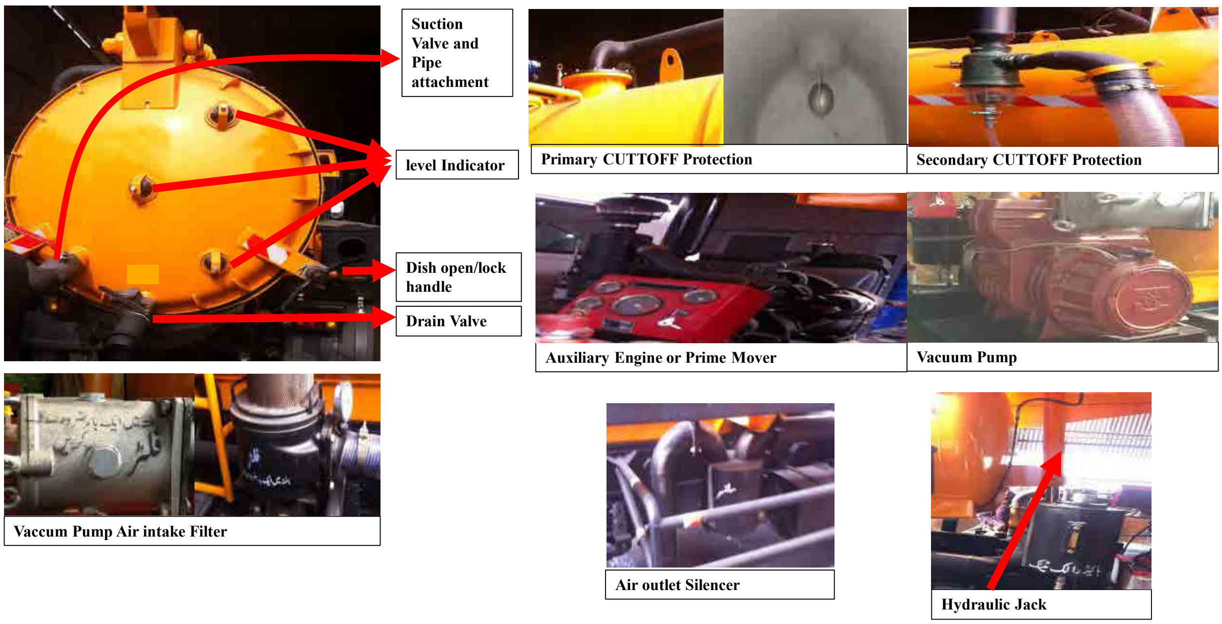


Parts No.	Description	Parts No.	Description
1	Auxiliary Engine	7	Secondary cutoff Protection
2	Vacuum Pump	8	Primary Cutoff Protection
3	Air Filter	9	Telescopic/Hydraulic Jack
4	Drain Valve	10	Dish Open/Lock Handle
5	Suction Valve	11	Silencer air exhaust from pump
6	Level Indicators	12	

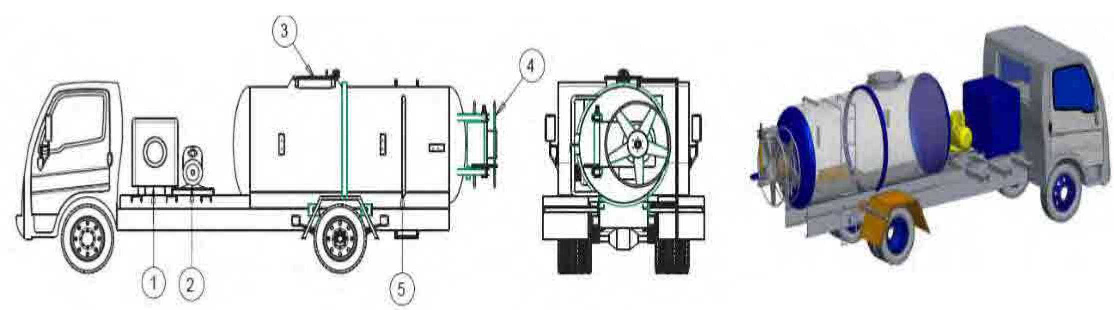
EXERCISE NO. 1: ASSEMBLY PARTS OF SUCKER MACHINE



EXERCISE NO. 1: ASSEMBLY PARTS OF SUCKER MACHINE

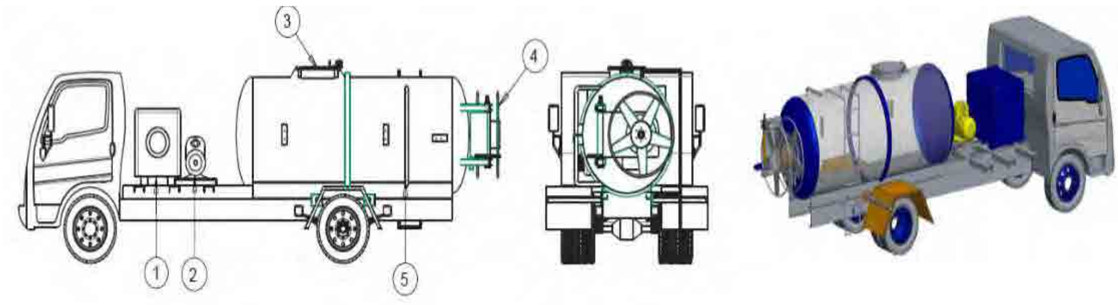


EXERCISE NO. 1: ASSEMBLY PARTS OF JETTER MACHINE



Parts No.	Description	Parts No.	Description
1		4	
2		5	
3		6	

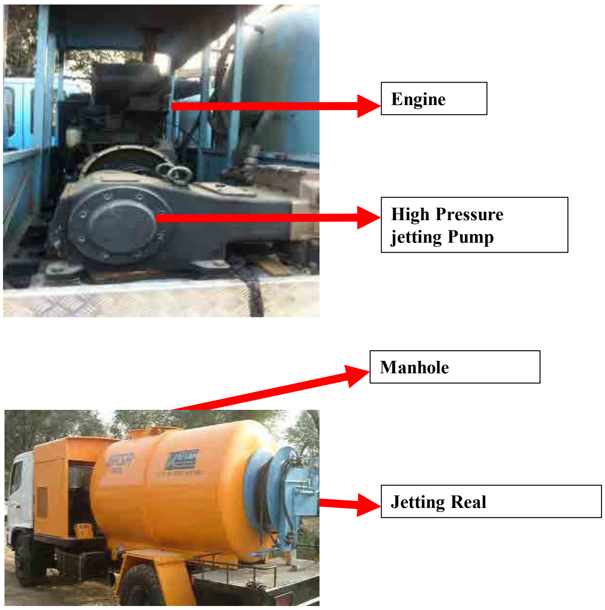
EXERCISE NO. 1: ASSEMBLY PARTS OF JETTER MACHINE



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	

EXERCISE NO. 1: ASSEMBLY PARTS OF JETTER MACHINE

EXERCISE NO. 1: ASSEMBLY PARTS OF JETTER MACHINE



EXERCISE NO. 1: DESCRIBE PURPOSE OF JETTER MACHINE

EXERCISE NO. 1: DESCRIBE PURPOSE OF JETTER MACHINE

- ✓ It is a high pressure, heavy duty three plunger pump mounted on a Nissan or Isuzu 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

EXERCISE NO. 1: DESCRIBE PURPOSE OF SUCKER MACHINE

EXERCISE NO. 1: DESCRIBE PURPOSE OF SUCKER MACHINE

- ✓ 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.
- ✓ Used to empty flooded sewerage lines and to clear blockage in combination with jetting unit

Course: ______________________________

Module: ______________________________

Training Date: ________________________

Trainee: ______________________________

Organization: _________________________

Email: _________________________________

Contact #: _____________________________

Module 3, Exercise 2

Question:

Find "severe condition maintenance items (minimum six items)" in the manual and indicate them on the provided list along with their interval and details. Please refer to provided list of items.

ISUZU F-Series Every 10 , 000 km Service Items

Sr. No	Maintenance Item	Interval and details
1	Fan belt tension and damage	
2	Valve clearance (Non Common Rail)	
3	Air cleaner element	
4	Drain fuel sedimentor	
5	Engine oil leakage and contamination	
6	Engine idling speed and acceleration	
7	Fan belt tension and damage	

Module 3, Exercise 2

i.e. Solution

29	Front wheel hub bearing oil	Change every 24,000 km (15,000 miles)
35	Brake lining for wear	Inspect every 6,000 km (3,750 miles)
37	Brake drum for wear and damage	Inspect every 24,000 km for wear (15,000 miles)
39	Leaf spring U-bolt nut	Retighten every 24,000 km (15,000 miles)
54	Engine oil	Change every 10,000 km (6,000 miles)
55	Engine oil filter	Change every 10,000 km (6,000 miles)

ISUZU F-Series Every 10 , 000 km Service Items

Sr. No	Maintenance Item	Interval and details
1	Fan belt tension and damage	
2	Valve clearance (Non Common Rail)	
3	Air cleaner element	
4	Drain fuel sedimentor	
5	Engine oil leakage and contamination	
6	Engine idling speed and acceleration	
7	Fan belt tension and damage	
8	Exaust pipes and all hoses/pipes in engine compartment for leak of damage	
9	Valve clearance (Non Common Rail)	
10	Engine coolant	
11	Cooling system for water leakage	
12	Clutch fluid	
13	Clutch pedal travel and free play	
14	Clutch system	
15	[4WD M/T] Manual transmission and transfer case oil leakage	
16	Transmission fluid	
17	[4WD A/T] Automatic transmission and transfer case oil leakage	
18	Propeller shaft loose connections	
19	Propeller shaft universal joints and splines for wear	
20	Front and rear axle oil leakage	
21	Differential gear oil	
22	[4WD] Front axle shaft rubber boot for damage	

23	Steering linkage for damage, looseness and excessive play	
24	Power steering oil leakage	
25	Steering column bolts for looseness or damage	
26	Power steering hose	
27	Differential gear and rear wheel hub bearing oil Inter differential gear oil	
28	Steering function	
29	Front wheel hub bearing oil	
30	Steering joint ball for oil leakage or damage	
31	Brake fluid	
32	Brake system for fluid leakage	
33	Brake function	
34	Front disc brake pads and discs wear/ lining and drum for wear	
35	Brake lining for wear	
36	Brake pedal travel and play	
37	Brake drum for wear and damage	
38	Parking brake function & cables for looseness or damage	
39	Leaf spring U-bolt nut	
40	Suspension mount for looseness or damage	
41	Shock absorbers for oil leakage	
42	Shock absorbers mount for looseness	
43	Rubber bushes of suspension wear or damage	
44	Tire air pressure and damage	
45	[F Series]Front brake lining and drum wear	
46	[F Series]Rear brake lining and drum wear	
47	[F Series]Brake Lining Adjust/ thickness	

48	[4WD] Propeller shaft universal joints and sliding sleeve	
49	[F Series]King pin	
50	[F Series]Center bearing, propeller shaft	
51	[F Series]Bushing, leaf spring	
52	[F Series]Water pump	
53	Tire Rotation	
54	Engine oil	
55	Engine oil filter	
56	Fuel filter	
57	Bolts and nuts on chasis and body	

Suction and Jetting Machines Operational Data

Suction Machine Operational Data

Max. Vacuum Pressure:
Air Filter Condition : **(Good or Bad)**

Sr. No.	Tank Capacity	Presuure Reading	Remarks

Jetting Machine Operational Data

Max. Jetting Pressure:
Y-Striner Condition (If Available) : (Good or Bad)

Sr. No.	Tank Capacity	Presuure Reading	Nozzle Type	Remarks

Please list three hazards and suggest measures to reduce or eliminate the risk involved.

Name:

Date:

Sr. No.	Hazard	Measures required	Comments
1			
2			
3			
4			

O & M of Mechanical Equipment WSD 5231

Water Meter Introduction and Selection

Module 4

Agenda

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

Agenda

- ✓ Selection of water meters
- ✓ Installation of water meters
- ✓ Maintenance of water meters

Icebreaker and class introduction

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

Icebreaker and Class Introduction

Now it is your turn…

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

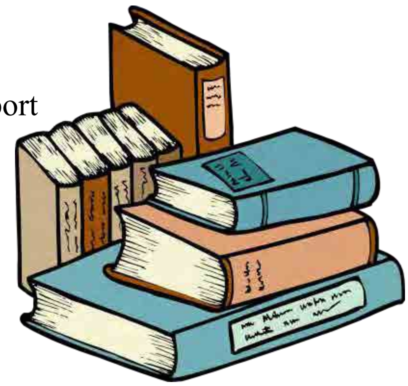
•Lecture notes

•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

WSD 5321, Mod 4 **11**

Meter application

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

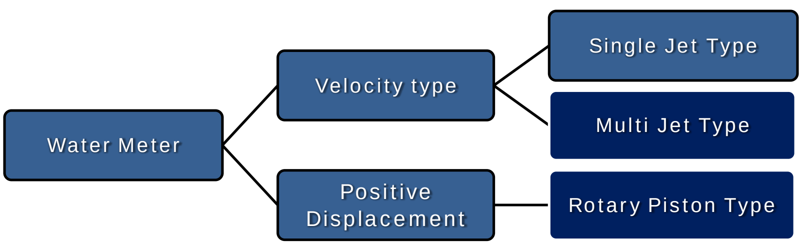
1. Consumer meters
2. Bulk transfer meters
3. Management meters

WSD 5321, Mod 4 **12**

Management meters

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

Major Water Meter Types in WASA (Consumer Meters)

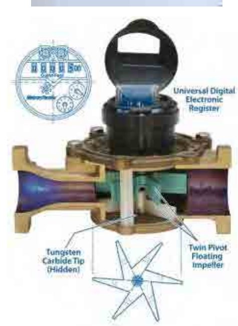


Dry type & Wet type

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

Single Jet Type

- The principle of operation is given by the incidence of a single tangential stream of water with a turbine mounted in a radial position within the body of the meter.
- The rotation of the turbine transmits the motion to the reading mechanism allowing the measurement of the volume of water passing through the meter.



Multi Jet Type

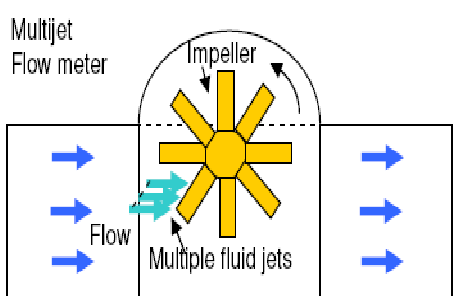
- The principle of operation is to force the passage of the inlet water flow through a series of ducts open in a capsule, called distributor, containing the turbine.

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

WSD 5321, Mod 4 17

Multi-jet meters

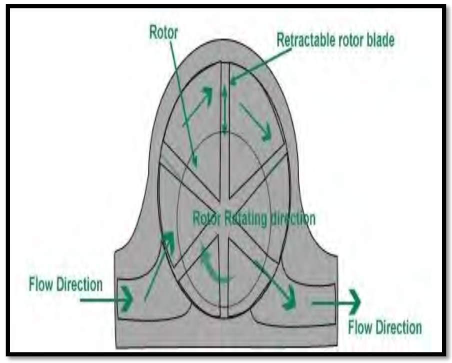
✓ They have tangential openings in a chamber to direct the water flow across a rotor with many vanes.



WSD 5321, Mod 4 18

Piston meters

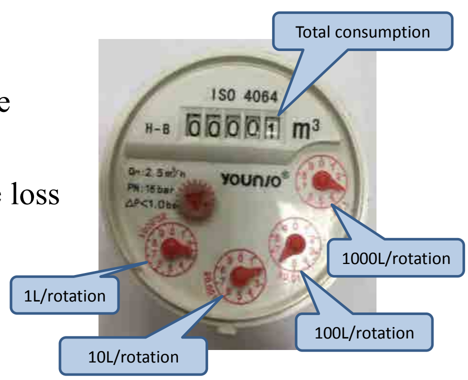
✓ They have a piston that oscillates back and forth as water flows through the meter.



Oscillating piston meter

Display of Water Meter

- ISO 4064: 1993
  - Qn : Nominal Flow Rate
  - PN : Nominal pressure
  - ΔP : 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:**

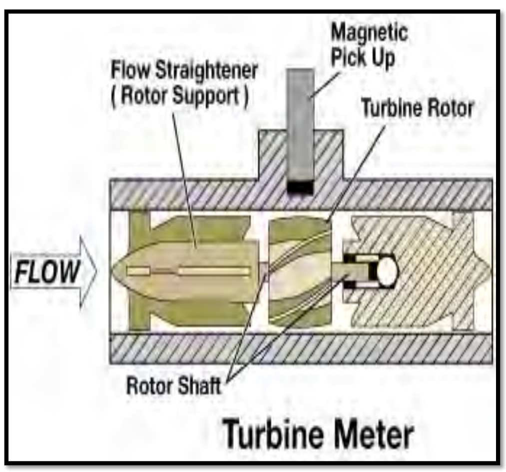
e.g.: The water meter shall conform to the pressure resistance performance.

Comparison of water meters

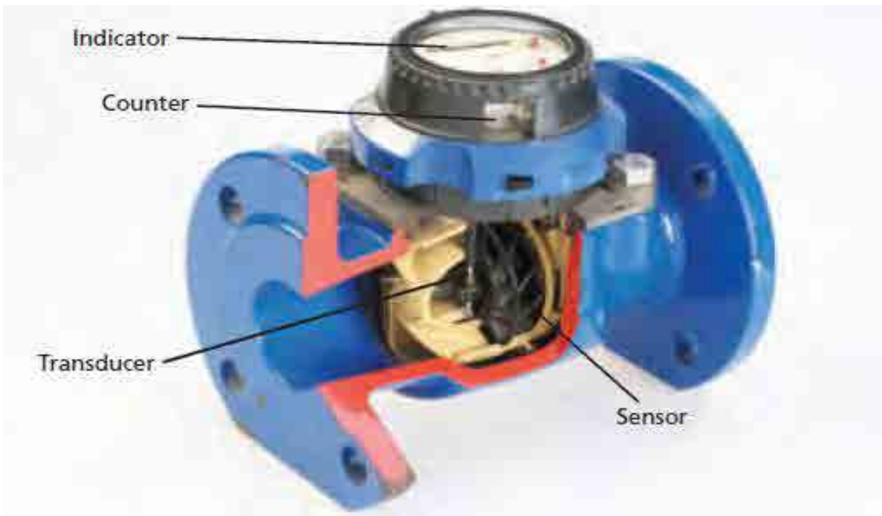
	Single jet (dry)	Multi jet (wet)	Rotary piston (wet)
Appearance			
Measuring method	Velocity	Velocity	Positive displacement
Structure	Simple structure	Complicated than Single jet	Complicated than others
Cost	Inexpensive	Inexpensive	More expensive than others
Others	Highly reliable operation	Small amount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

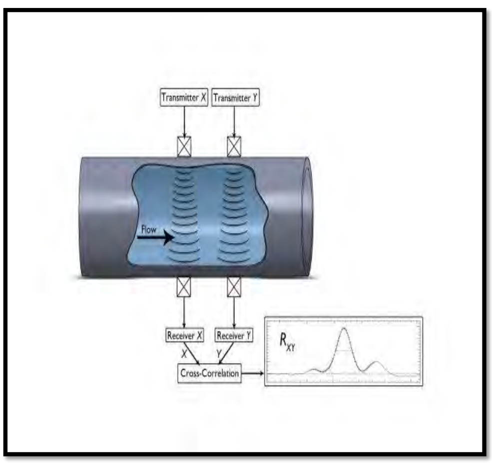


Section through a flow meter showing the sensor, transducer, counter and indicator (meter supplied by Sensus)



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.



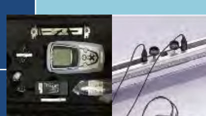
Ultrasonic meter

Magnetic meter

- ✓ They have an insulated sec through which water flows.
- ✓ The flow of water induces electrical current that proportional to the velocity hence the flow rate.

Magnetic water meter

Comparison of Flow meters

	Ultra Sonic	Electromagnetic	Turbine
Appearance			
Accuracy	in small flow rate	i	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

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

Water Meter Installations

Current conditions?

- Water meter is a measuring device which is used to measure the amount of water..
- Water meter is installed to reduce the Non revenue Water .
- There are many connections, which account for NRW (before meter)
- We should installed water meter outside the home for ease of access

37

Multi-jet water meter type

- In this Impeller and register are magnetically couple . It is designed to be installed horizontally to ensure the desired meter accuracy.

38

Installation of water meter

Wrong Installation (Vertically)

Correct Installation (Horizontally)

39

How should be water meter install?

- This water meter should be installed horizontally.

WHY?

In this vertical connection, distance between two magnets could alter, causing decreased accuracy.

40

Water Meter Installation Assembly (class exercise hands-on)

Water Meter Installation Assembly (class exercise hands-on)

Water Meter Installation Assembly (class exercise hands-on)

WSD 5321, Mod 7

43

Water Meter Installation Assembly (class exercise hands-on)

WSD 5321, Mod 7

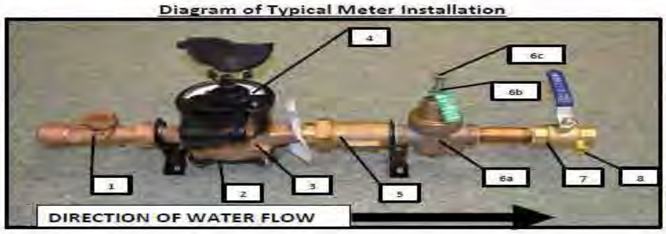
44

Water Meter Installation Assembly (Horizontal)

Water Meter Installation Assembly (Vertical)

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.

Course: ____________________________

Module: _____________________________

Training Date: ______________________

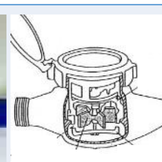
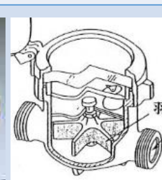
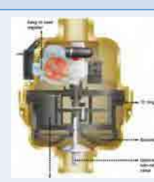
Trainee: ____________________________

Organization: _______________________

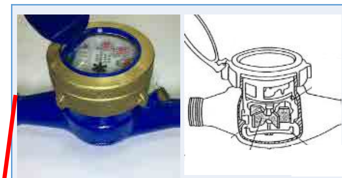
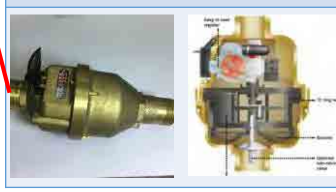
Email: _______________________________

Contact #: ___________________________

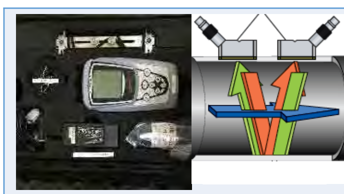
Module 4, Exercise 1 (Water Meter Types)
Please connect correct items in all 3 columns

Single Jet Type (Dry Type)			Simple design, competitive price and highly reliable operation.
Rotary Piston Type (Wet Type)			Accuracy is better than others but structure is complicated and expensive.
Multi Jet Type (Wet Type)			Accuracy is good even with small amounts of flow rate

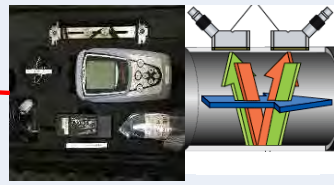
Exercise 1, Water Meters Types, Solution

Single Jet Type (Dry Type)		**Simple design, competitive price and highly reliable operation.**
Rotary Piston Type (Wet Type)		**Accuracy is better than others but structure is complicated and expensive.**
Multi Jet Type (Wet Type)		**Accuracy is good even with small amounts of flow rate**

Module 4, Exercise 1 (Flow Meter Types)
Please connect correct items in all 3 columns

Ultra Sonic Flow Meter		**Simple structure and inexpensive. There is a pressure loss.**
Electromagnetic Flow Meter		**There is almost no pressure loss. Susceptible to electrical noise.**
Turbine Flow Meter		**There is no pressure loss. Poor accuracy in small flow rate.**

Exercise 1, Flow Meter Types, Solution

Ultra Sonic Flow Meter		Simple structure and inexpensive. There is a pressure loss.
Electromagnetic Flow Meter		There is almost no pressure loss. Susceptible to electrical noise.
Turbine Flow Meter		There is no pressure loss. Poor accuracy in small flow rates.