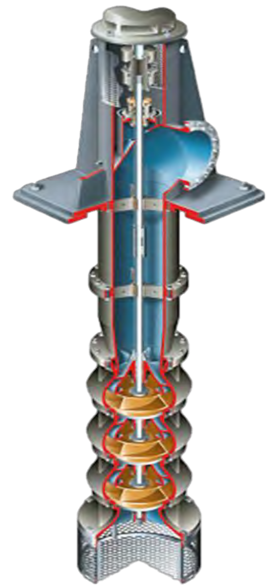
Annex 5.1.29 Training Material: "O&M on Pump" for ToT at WASA Rawalpindi

Operation and Maintenance of Pump

WASA Tube well/Disposal Station



Operation and Maintenance of Pump

- **Operation of system**
- Ensuring effective routine running of system timely and daily.
- Stability
- Efficient
- Safely

- **Maintenance**
- Keep of structures/system including planned
- Preventive or Corrective maintenance
- Repair

Operation and Maintenance plan

Operation Record and Manual

- Keep a operational record continuously.
- Prepare a O&M Manual (SOP).

Improvement of Operational Control

- Understand / follow the O&M Manual (SOP).
- Detect any abnormalities and take measures.

Control of Water Amount and Pressure

- Establish a proper control method of equipment.
- Prevent from water leakage.

Operation and Maintenance Plan

- **Preparation of O&M Plan**
- Preparation of a plan involves list of routine tasks, specific tasks at regular intervals including inspection of system (Daily, Weekly, Quarterly, Annually etc.)
- Plan also involves a checklist for operation, supervision and maintenance.

Standard Operating Procedure for Pump

- **1.**Check on the panel door the 3 indicator lights are illuminated. If the indicator lights are off check the position of Main breaker. Turning the main breaker On will illuminate the indicator lights. But if the situation remains the same then there will be shut off from Wapda's side.
- پینل کے دروازے پر چیک کریں کہ 3 انڈیکیٹر لائٹس روشن ہیں۔ اگر اشارے کی لائٹس بند ہیں تو مین بریکر کی پوزیشن چیک کریں۔ مین بریکر آن کرنے سے اشارے کی روشنی روشن ہو جائے گی۔ لیکن اگر صورتحال یہی رہی تو واپڈا کی طرف سے بجلی بند کر دی گئی۔

- **2.**Check the indicator light status of (Over Load Trip).

2. (اوورلوڈ ٹرپ) کے اشارے کی روشنی کو چیک کریں۔

- **3.** Check the indicator light status of(Dry Running trip).

(Dry Running trip) کے اشارے کی روشنی کو چیک کریں ۔

Standard operating procedure

- **4.**Check the indicator light status of (Earth leakage trip).

(Earth Leakage Trip) اشارے کی روشنی کو چیک کریں۔

- **5.**You can only start the pump if all the above four indicator lights are in off state.In case anyone of above light is in on state do inform the respective operation supervisor.
- آپ پمپ کو صرف اس صورت میں شروع کر سکتے ہیں جب اوپر دی گئی چاروں اشارے کی لائٹس بند ہوں۔ اگر اوپر کی کوئی روشنی چل رہی ہو تو متعلقہ آپریشن سپروائزر کو مطلع کریں۔

- **6.** Before Pump start check main braker on or not?

مین بریکر آن ہیں یا نہیں؟

- **7.**The (Duty selector switch) is in ON position.

ڈیوٹی سلیکٹر سوئچ آن ہو۔

Standard operating procedure

- **8.**Power Factor switch should be on Auto position.

8پاورفیکٹرسوئچ آٹوپوزیشن پر ہونا چاہئے۔

- **9.**Before Starting the pump open valve of water lubrication tank and close it after it goes empty.

پمپ کو چلانے سے پہلے بلکسس سے پانی لیں اور خالی ہونے کے بعد اسے بند کو دیں۔

- **10.**Press ON(Green) button pump will start.

ON(سبز)بٹن کو دبائیں پمپ چلنا شروع ہو جائے گا۔

Standard operating procedure

- **11.**After starting the pump, ON the Chlorine dosing pump to start the dosing of Chlorine.

پمپ چلانے کے بعد کلورین پمپ چلائیں۔

- **12.**After starting the main pump make sure the complete absence of abnormal noise or vibration in motor and pump. In occurrence of any such behavior immediately inform the respective site supervisor.

پمپ شروع کرنے کے بعد موٹر اور پمپ میں غیر معمولی شور یا وائبریشن کی جانچ کریں ایسے
کسی بھی ہونے کی صورت میں فوری طور پر متعلقہ سائٹ سپروائزر کو مطلع کریں۔

Daily operation Record

- **Daily operation record Parameters**
- Pump capacity
- Total Head
- Discharge pressure
- Chlorinator setting
- Motor heating, Noise
- Voltage(V),Ampere(A),Motor Output(KW)
- Leakage

Daily Operation Record Sheet (Tube Well Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity:	L/hr	Approved by (Engineer)	
Rated Voltage:	V	Chlorinator Setting:	%	Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Flow Meter Reading (Start)	m^3									
6	Flow Meter Reading (Stop)	m^3									
7	Flow Amount (No.6 - No.5)	m^3									
8	Pressure Gauge Reading	Bar / MPa									
9	Voltage	V									
10	Ampere	A									
11	Operation of Chlorinator	Done / Not									
12	Motor Heating	Normal / High									
13	Abnormal Sound/Noise	Yes / No									
14	Leakage	Yes / No									
15	Remarks										

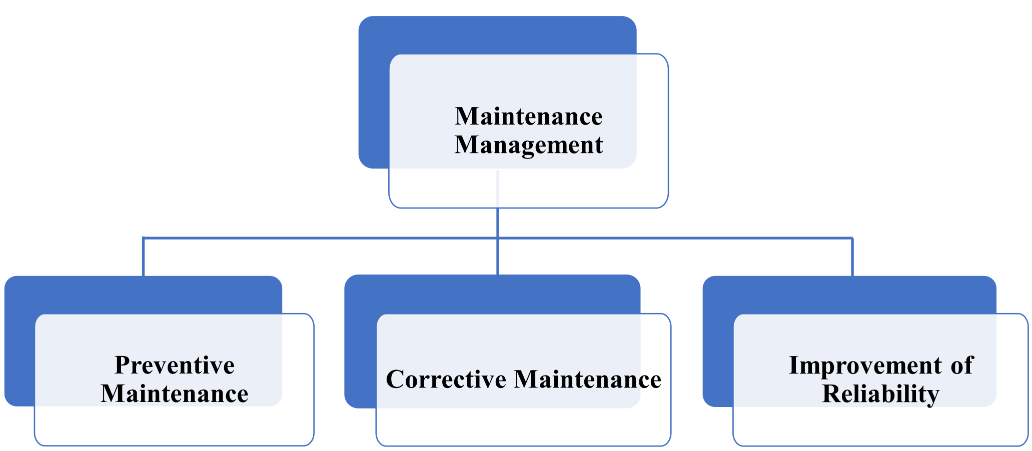
Daily Operation Record Sheet (Disposal Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW			Approved by (Engineer)	
Rated Voltage:	V			Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Suction Pressure	Bar / MPa									
6	Discharge Pressure	Bar / MPa									
7	Voltage	V									
8	Ampere	A									
9	Motor Heating	Normal / High									
10	Abnormal Sound/Noise	Yes / No									
11	Leakage (except pump)	Yes / No									
12	Cleaning of Screen	Done / Not									
13	Remarks										

Maintenance Management of Pump

- Maintenance Management is categorized into the following items;



Parameters for Monthly/Yearly inspection(Preventive maintenance)

- Pump capacity
- Total Head
- Chlorinator capacity/setting
- Gland packing leakage
- Voltage(V),Ampere(A),Motor Output(KW)
- Oil Level/Grease
- Operation of discharge valve
- Vibration
- Insulation
- Connections
- Overhaul

Monthly Inspection Record Sheet (Vertical Pump)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Inspection Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity: (only for Tube Well)	L/hr	Approved by (signature)	
Rated Voltage:	V	Chlorinator Setting: (only for Tube Well)	%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Result	Standard	Remarks
1	Leakage Amount at Grand Packing	mL/min	Proper / Not	q = 0.5 × d (mm, shaft dia.)	
2	Dosing Amount of Chlorine Solution	L/hr	Proper / Not	According to the caluculation sheet	Only for Tube Well
3	Oil Level	-	Proper / Not	According to the level gauge	

S-No.	Check / Maintenance Items	Unit	Result	Remarks
4	Retightening of Grand Packing	-	Done / Not	In case that leakage amount is excess.
5	Adjusting the setting value of Chlorinator	-	Done / Not	In case that the measured value does't meet the calculated value.
6	Refilling Oil	-	Done / Not	In case that oil level is low.
7	Operation of Discharge Valve	-	Functioning / Not	

< Comments / Findings>

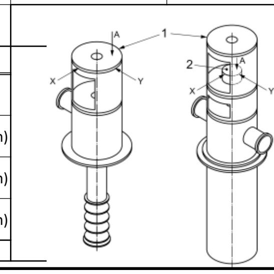
Yearly Inspection Record Sheet (Vertical Pump)

Pump Capacity:		cusec	Rated Ampere:		A	Location / Code:	
Total Head:		m	Rated Rotation Speed:		rpm	Inspection Date:	/ /
Rated Motor Output:		kW	Chlorinator Capacity: (only for Tube Well)		L/hr	Approved by (signature)	
Rated Voltage:		V	Chlorinator Setting: (only for Tube Well)		%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Measurement Location/Direction*		Measured Value	Standard Value*	Remarks
1	Vibration	mm/s	1 (Drive Mounting Surface/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
			2 (Pump Bearing/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
2	Insulation	MΩ	** According to the electrical inspection sheet				

S-No.	Maintenance Items	Result	Remarks
3	Retightening of Anchor Bolts	Done / Not	
4	Replace of Grand Packing	Done / Not	every 1 to 4 years (depending on the condition)
5	Replace of Oil/Grease	Done / Not	every 1 to 4 years (depending on the condition)
6	Overhaul	Done / Not	every 1 to 4 years (depending on the condition)

< Comments / Findings>



Instruments use for Inspection

- Vibration meter
- Clamp meter
- Insulation meter

Troubleshooting of Pump

Annex 5.1.30 Training Material: "O&M on Pump" for Pilot In-house Training and In-house Training at WASA Rawalpindi

Operation and Maintenance (O&M) OF PUMP

Table of Contents

Purpose and Outline of O&M Activity

1. Purpose of O&M Activity

- To **provide satisfactory and sustainable services** of water supply and sewerage for consumers.
- To **continue efficient and safe operational management** of pump facilities.
- To **conduct necessary inspection and maintenance**.

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

O&M of Water Supply and Sewerage Facilities/Equipment consists of the following two elements.

- **Operation Management**
- **Maintenance Management**

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Operation Management is

- ✓ To operate and control each facility/equipment.
- ✓ To operate and control related facility/equipment as an integrated system effectively.
- ✓ To fulfill its function sufficiently.

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Maintenance Management is

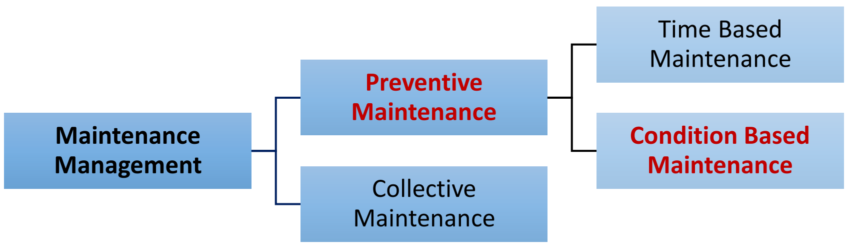
- ✓ To complement function degradation of equipment and maintain its original function.
- ✓ To decrease **Life Cycle Cost (LCC)** of equipment by prolongation of its lifetime etc.

LCC means the total cost which includes;
- Initial Cost (Construction Cost)
- Running Cost (Total O&M Cost during the Life Time)
- Disposal / Demolition Cost

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Maintenance Management is categorized into the following items;



Purpose and Outline of O&M Activity

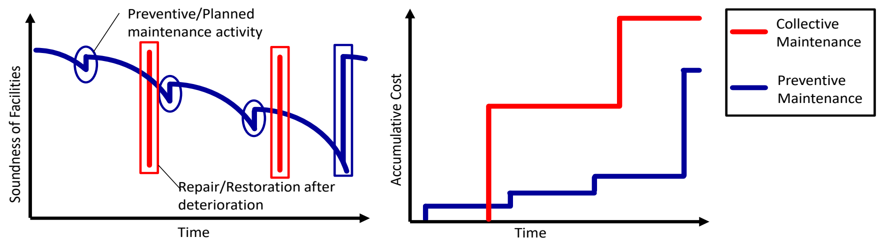
2. Outline of O&M Activity

- **Preventive Maintenance** is preliminary maintenance activities to prevent from malfunction of equipment. It can be categorized into the followings.
  - ✓ **Time Based Maintenance (TBM):**

    Maintenance activities are performed based on the **planned period**.
  - ✓ **Condition Based Maintenance (CBM):**

    Maintenance activities are performed through the **planned inspection to check deterioration/operation condition**.
- **Collective Maintenance** is repair / restoration work after malfunction.

Importance of Preventive Maintenance



Source: Japan's Experiences on Water Supply Development (JICA)

Merits of Preventive Maintenance are

- To **minimize the LCC** of equipment
- To **prolong the lifetime** of equipment

Standard Operation Procedure (SOP) of Pump

1. Typical System of Pump Equipment

Volute Pump (Vertical Turbine)

Flow Meter
(Electro Magnetic Type)

Standard Operation Procedure (SOP) of Pump

1. Typical System of Pump Equipment

Mixed Flow Pump

Mixed Flow Pump (Vertical)

Inlet Gate

Discharge Valve & Check Valve

Screen

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Before Operation

i. Check a leakage or other abnormality at the pump area.

ii. Select the pump to be operated.

iii. Check the related valves are at the proper position.

iv. Check the lubricate water tank is filled with water.

v. Check the pressure gauge indicates the original/zero value.

vi. Check/record the Voltage, Ampere of power incoming on the electrical panel.

vii. Check/record the flow meter reading and water level of the related tanks (if necessary).

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Start Operation

i. Push the start button at the electrical panel.

ii. Open the discharge valve slowly.

iii. Check/adjust the flow rate and discharge pressure to the design value (indicated in the specification).

iv. Check/record the start time, discharge pressure, Voltage and Ampere etc. in accordance with the Record Sheet.

Note) In case the pump is operated frequently, keep open the discharge valve and skip the above procedure of ii.

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Stop Operation

i. Push the stop button on the electrical panel.

ii. Check/record the flow meter reading and stop time.

iii. Close the discharge valve.

(In case the pump is stopped for a long time.)

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Before Operation

i. Check a leakage or other abnormality at the pump area.

ii. Select the pump to be operated.

iii. Check the related valves are at the proper position.

iv. Check the pressure gauge indicates the original/zero value.

v. Check/record the Voltage, Ampere of power incoming on the electrical panel.

vi. Check / record the flow meter reading and water level of the related tanks (if necessary).

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Start Operation

i. Push the start button at the electrical panel.

ii. Open the discharge valve slowly.

iii. Check/adjust the flow rate and discharge pressure to the design value (indicated in the specification).

iv. Check/record the start time, suction/discharge pressure, Voltage and Ampere etc. in accordance with the Record Sheet.

Note) In case the pump is operated frequently, keep open the discharge valve and skip the above procedure of ii.

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Stop Operation

i. Push the stop button on the electrical panel.

ii. Check/record the stop time.

iii. Close the discharge valve.

(In case the pump is stopped for a long time.)

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

- ✓ Abnormal noise and vibration (by hearing/touching)
- ✓ Heat generation of motor (by touching)
- ✓ Discharge pressure, flow rate/amount (by checking pressure gauge, flow meter etc.)
- ✓ Leakage

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

Excessive heat generation of motor can be checked by sense of touch.

Surface Temperature	Sense of Touch	Remarks
40 ℃	Somewhat warm	Feel slightly warm.
45 ℃	Warm	Feel comfortably warm.
50 ℃	Somewhat hot	Your palm turns red if you touch it for a few minutes.
60 ℃	Hot	Can hold your hand for a few seconds.
70 ℃	Extremely hot	Can hold one finger for a few seconds.
80 ℃	Extremely hot	Can hold one finger for only one second.

Normal condition

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

✓ Voltage and current (by checking voltage/ampere meter on the electrical panel)

How to Conduct Daily Inspection

2. Daily Inspection Points of Mixed Flow Pump

- ✓ Same points as Volute Pump
- ✓ Suction pressure (if suction pressure gauge is installed.)

How to Conduct Daily Inspection

3. Record Keeping

Daily inspection results and other operation records shall be noted down in the Record Sheet surely and properly.

Daily Operation Record Sheet (Tube Well Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:			
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /		
Rated Motor Output:	kW	Chlorinator Capacity:	L/hr	Approved by (Engineer)			
Rated Voltage:	V	Chlorinator Setting:	%	Prepared by (Operator)			

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Flow Meter Reading (Start)	m^3									
6	Flow Meter Reading (Stop)	m^3									
7	Flow Amount (No.6 - No.5)	m^3									
8	Pressure Gauge Reading	Bar / MPa									
9	Voltage	V									
10	Ampere	A									
11	Operation of Chlorinator	Done / Not									
12	Motor Heating	Normal / High									
13	Abnormal Sound/Vibration	Yes / No									
14	Leakage	Yes / No									
15	Remarks										

How to Conduct Periodic Inspection

1. Monthly Inspection Points of Volute/Mixed Flow Pump

- ✓ Leakage amount at Grand Packing
  - ➢ Criterion: q [mL/min] = 0.5 × d (mm, shaft dia.)
  - ➢ In case leakage amount is excess, retightening shall be done.
- ✓ Dosing amount of chlorine solution
  - ➢ In case the measured value doesn't meet the target value, it is necessary to adjust the setting value of Chlorinator.
- ✓ Oil level
  - ➢ In case oil level is low, refilling shall be done.
- ✓ Operation of Discharge Valve

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

- ✓ Vibration measurement
- ✓ Insulation measurement
- ✓ Retightening of Anchor Bolts
- ✓ Replace of Grand Packing
  - ➢ every 1 to 4 years (depending on the condition)
- ✓ Replace of Oil/Grease
  - ➢ every 1 to 4 years (depending on the condition)
- ✓ Overhaul
  - ➢ every 4 to 7 years (depending on the condition)

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

- **Purpose**
  To check/evaluate whether a pump is functioning in desirable condition.
- **Standard/Regulation**
  ISO 10816-7 (2009)
- **Feature**
  Vibration measurement is used for fault diagnosis of pump. **Unbalance** and **misalignment** can be detected by measuring **vibration velocity**, and **abnormality of bearing** can be detected by measuring **vibration acceleration**.

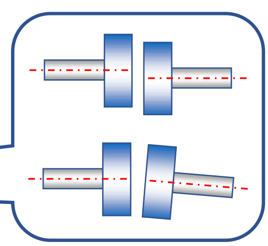
How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

- **Major Causes of Vibration**

✓ Unbalance
✓ Misalignment
✓ Abnormality of Bearing
✓ Cavitation
✓ Loosening of Anchor (Foundation) Bolt



Source: Website of NTN Corporation, Japan

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

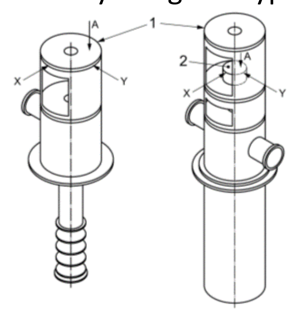
< Vibration Measurement >

● **Procedure**

i. Prepare/set up a vibration meter. (Basically magnet type sensor shall be used.)

ii. Select/decide the measurement locations based on the right figure.

iii. Measure/record vibration velocity value [mm/s] at the selected locations with three directions (axial, vertical, horizontal).



Notes)
Location 1: Driver mounting surface/lower motor bearing
Location 2: Pump bearing housing

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

● **Evaluation**

The results shall be evaluated according to the below table.

Zone	Description	Vibration Velocity Limit*	
		≤ 200 kW**	> 200kW**
A	Newly commissioned machine	3.2	4.2
B	Unrestricted long-term operation	5.1	6.1
C	Limited operation	8.5	9.5
D	Risk of damage	> 8.5	> 9.5

Notes)
* *The root-mean-square (r.m.s) value in mm/s*
** *The applicable motor capacity of industrial pump, which is categorized into Category II (pumps for general or less critical application), is above 1 kW.*

How to Conduct Periodic Inspection

3. Record Keeping

Monthly and yearly inspection results shall be noted down in the Record Sheet surely and properly.

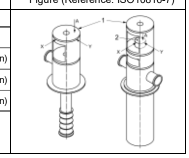
Yearly Inspection Record Sheet (Vertical Pump)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Inspection Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity: (only for Tube Well)	L/hr	Approved by (signature)	
Rated Voltage:	V	Chlorinator Setting: (only for Tube Well)	%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Measurement Location/Direction*		Measured Value	Standard Value*	Remarks
1	Vibration	mm/s	1 (Drive Mounting Surface/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
			2 (Pump Bearing/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
2	Insulation	MΩ	** According to the electrical inspection sheet			* Figure (Reference: ISO10816-7)	

S-No.	Maintenance Items	Result	Remarks
3	Retightening of Anchor Bolts	Done / Not	
4	Replace of Grand Packing	Done / Not	every 1 to 4 years (depending on the condition)
5	Replace of Oil/Grease	Done / Not	every 1 to 4 years (depending on the condition)
6	Overhaul	Done / Not	every 4 to 7 years (depending on the condition)

< Comments / Findings>



Planning of Periodic Inspection & Maintenance

- Periodic inspection and maintenance shall be conducted for all pumps surely and properly.
- Plan of periodic inspection and maintenance shall be made in the previous year considering the following points.
  - ✓ **Installation year** (Aged pump shall be checked carefully.)
  - ✓ **Importance/Priority** (Pumps have big impacts in case of malfunction/shutdown.)
  - ✓ **Location** (Moving time shall be minimized.)
  - ✓ **Time required** (Monthly inspection: within one hour, Yearly inspection: depending on the condition)
  - ✓ **Cost** (In case of overhaul, replace of major parts etc.)

Annex 5.1.31 Supplemental Material for WTP at WASA Rawalpindi: Major Points of O&M

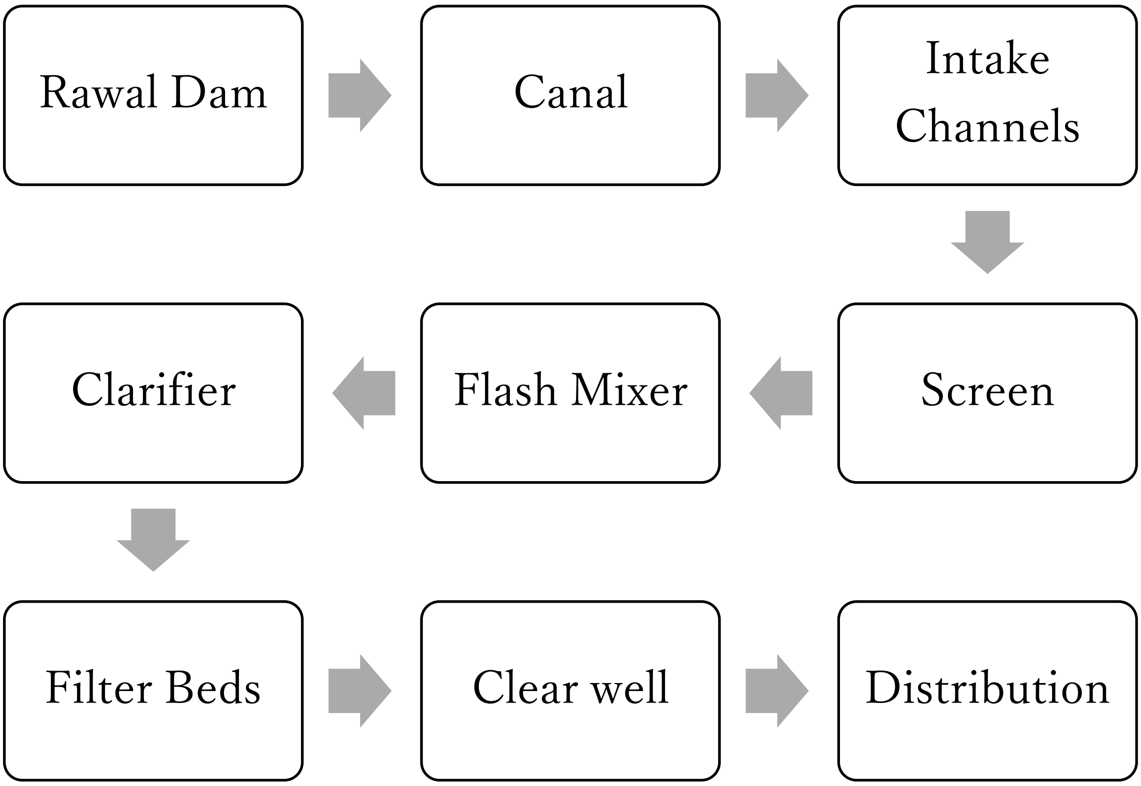
Major Points of Operation and Maintenance (O&M) for Water Treatment Plant WASA, Rawalpindi (RLWTP)

THIS DOCUMENT IS PREPARED FOR TRAINING PURPOSES. IT CONTAINS A SAMPLE PREVENTIVE MAINTENANCE PLAN FOR THE WATER TREATMENT PLANT. IT IS HIGHLY RECOMMENDED TO USE MANUFACTURER'S MANUALS FOR PREVENTIVE MAINTENANCE.

JICA Expert Team

Contents

Flow Diagram



Designed Parameters

Capacity:	28 MGD (existing 23 MGD)
Intake:	Rawal Dam

Treated Water Quality:

Turbidity	< 1 FTU (24 hr Average)
Color	< 5H
pH	= 7.5 ~ 9.5
Residual Chlorine	= 0.3 ~ 1 mg/L

Components:

Raw Water Intake Channels

Screens (Coarse Hand Rake Bar) x 3

Flow measurement and control chambers

Butterfly Valves (Electric Actuated)

Flow Measures (Venturi and Magnetic)

Raw water Aeration

Blower (Air Flow = 6 m^3 / min) x 2

Flash mixer/ Distribution chamber

Geared Drives x 2

Mixer (Shaft Mounted)

Clarifier (Round Shape)

Flocculator x 2

Sludge Scrapper

Clarifier Area	= 475 m^2
Up flow velocity	= 2.55m/hr
Flow	= 336 L/s
Clarification Rate	= 6.39 MGD/ Clarifier

Clarifier (Rectangular Shape)

Clarifier Area	= 4 x 190 = 760 m^2
Up flow velocity	= 2.2 m/hr
Flow	= 475 L/s
Hydraulic Flocculator	
Sludge concentrators	
Clarification Rate	= 9.03 MGD

Filters

Rapid Sand Gravity (Constant Head)

Media (Silica Sand 0.95mm, Effective Size, 1.4 m thick layer)

Filtration Rate MAX: 6.5 m/h, AVE: 5.4 m/h

Outflow turbidity < 1 NTU

Output Flow = 7.9 ML/d/ filter

Rate of filtration = 110 G/ft2/h

Backwash system

Combined air and water washing

Air scour rate = 30 m/h

Water Wash rate = 22 m/h

= 40 m/h

Nozzles opening = 0.2 mm

Backwash time = 13 -20 min/ filter

Coagulation

15 % Aluminum Sulphate Solution

Disinfection

Chlorine injection by means of chlorinators with range 2-20 kg/ hr

Chlorine supply: 1 ton drums liquid chlorine

Chlorine dosing

Gas

Major Points of O&M for RLWTP

1. Primary Screen

The function of primary screen is to stop large floating objects to get inside the intake channel. However, screen must be monitored regularly to see whether any foreign objects are stuck with the vertical bars and if so, remove promptly.

2. Flash Mixer

1) Operation of Flash Mixer

- ✓ Check whether the blades of Flash Mixer are submerged.
- ✓ Push the start button to start the flash mixer.
- ✓ Check and confirm for smooth operation of Flash Mixer.
- ✓ Push the stop button to stop the Flash Mixer.

Notes) In case Alum is not injected during low turbidity season, the mixer can be stopped for energy saving purpose.

2) Inspection/Maintenance of Flash Mixer

- ✓ Daily and periodic inspection shall be performed according to the below table, and the results shall be recorded in logbook/mWater form.

Table: Inspection Points of Flash Mixer

Points of inspection & maintenance	Frequency
Oil level and its leakage	Daily
Current and Voltage	
Excessive heat generation of motor	
Abnormal noise, vibration	
Operating condition	

Check/retightening of anchor bolts	Monthly
Complete change of lubricant and grease	In accordance with the instruction manual

3. Clarifier

1) Start-up & Operation Procedures

- ✓ Perform a jar test on the influent raw water to determine the appropriate chemical dosages. Since this test is essential for good treatment, the plant operator should enter the test results in the proper logs and records to ensure the appropriate information is available to all stakeholders.
- ✓ Complete a general inspection of the clarifier systems. Note and report any equipment in need of maintenance or repair.
- ✓ Check and confirm that each inlet gate of each flocculator to be used is open.
- ✓ Check and confirm that each de-sludge valves of each clarifier to be used is closed.
- ✓ Based on the jar test results, prepare the necessary chemical feed systems for start-up.
- ✓ Inform the concerned operation staffs to take necessary steps of valve operation to fed raw water to receiving wells from raw water conveyance.
- ✓ Alum shall be injected on regular basis. Lime and Chlorine shall be dosed depending on the jar test results and growth of algae at flocculator and clarifier walls.
- ✓ From the mixing chamber, raw water with mixed chemicals shall be fed to the clarifier where the flocculated solids settle down as sludge.

Observation, Monitoring and Sludge Removal

- ✓ There should not be any floating objects in the clarifier. If any, it should be removed promptly.
- ✓ Coagulation, flocculation, and sedimentation condition of suspended solids shall be checked. If the results are found not satisfactory, dosage rate of alum & lime shall be adjusted. It is recommended for operation to control the pH at flocculation around 7.0. Chemical dosing rate have to be determined by jar test.
- ✓ Sludge shall be withdrawn from each tank, through de-sludge valves.
- ✓ Each of the clarifiers shall be cleaned and washed out at least twice a year. However, the schedule of cleaning may be determined based on process requirements. In general, one after another so plant operation can continue at full capacity.

Table: Inspection and Maintenance Schedule

Facility	Contents of inspection & maintenance	Frequency
Receiving Well	Check and confirm flow rate of raw water	Daily
	Check and confirm quality (turbidity, pH, alkalinity) of raw water	
	Perform jar test on raw water samples when significant raw water quality changes are experienced. Adjust coagulant dosages.	
	Check and confirm condition of mixing	
	Calibrate chemical feeders	Monthly
	Check for cracks, deterioration of concrete, existence of leaks	Yearly
	Operation status of respective types of valves, gates, & mixer etc.	

	Cleaning and maintenance of receiving well & mixing chamber	
Clarifier	Check and confirm proper growth of flocs	Daily
	Check settling condition of flocs	
	Check and confirm settled water quality (turbidity)	
	Check for existence of trash, algae etc.	
	Check for cracks, deterioration of concrete, existence of leaks	Yearly
	Operation status of respective types of valves, mixers and sludge collectors.	
	Touch-up paint of valves and other machinery	
	Cleaning and maintenance of Clarifier	

2) Start-up & Operation Procedures of the mixer and sludge collector (For the Circular Clarifiers)

- ✓ Ensure all relevant main switches for mixers and sludge collectors are energized.
- ✓ Turn on applicable control power. Except for maintenance, mixers and sludge collectors should always be running.
- ✓ Visually check the operating condition of mixers and sludge collector.

Table: Checklist for Mixers and Sludge Collectors

Timing	Points to be checked
Before starting operation	Power supply, voltage and capacity are suitable.
	Wiring is connected properly.
	Bearing's oil and grease are enough.
During operation	Drive-current is normal.
	Is there any strange sound and vibration during operation?
	Is there any strange sound from bearing and oil seal?
	Is there any strange smell and smoke?
	Surface temperature of driving units are normal.

4. Rapid Sand Filter (RSF)

1) Operation Procedures of Filtration

- ✓ During the filtration process, the inlet and outlet valves shall be opened.
- ✓ The following points shall be checked/performed properly.

Table: Daily O&M of RSF

Points to be checked	Notes
Observe the water level in the RSF	When the water level in the filter reaches the pre-set level for the start of the backwashing of filters, the backwashing process shall be started.
Remove any floating materials	Use net or any other suitable tools
Measure turbidity, pH, EC, TDS and residual chlorine etc. of treated water collected at the entrance of the clear water tank (effluent of the filters)	Note down the results in a logbook/mWater form. If the value of any parameter is found more than the standard value, investigate the cause of such value and take necessary countermeasure.
Check and confirm filtration rate (ave: 5.4m/hr., max:6.5m/hr.), and filter run time. Same filtration rate from the clarifier to all filters shall be maintained.	Same height of water above influent weir installed at inlet of each filter shall be confirmed by adjustment (if necessary) of inflow valve or influent weir.

2) Operation Procedures of Backwash

There are two conditions for filter backwash. The first condition is the design high water level. The need for filter backwashing is determined by closely monitoring the individual water level of each filter. When the level in filter reaches the highest design level, the filter is ready to be backwashed. The second condition is time. An RSF should be backwashed at least once every 24-hour. Nevertheless, the filters are to be backwashed only one at a time.

- ✓ Close the inlet valve of the target RSF and wait until the inside water level goes down to the designed level (below the effluent trough). When the water level reaches to the designed value, the outlet valve shall be closed.
- ✓ Air scouring is performed by operating the related valves and air blower for at least 5 minutes. However, this value shall be adjusted depend on the effectiveness of air scouring. The design velocity is 30 m/hr.
- ✓ Only backwash is performed by operating the related valves and backwash pump for approx. 10 min in order to wash out the suspended matters removed from the filter sand by air scouring. The design velocity is 22 or 40m/hr., and the backwash period shall be adjusted depend on the effectiveness of backwash (The appearance of surface water shall be clean enough.).
- ✓ After the backwash pump is stopped, the Air Vent Valve shall be opened to exhaust the remaining air. After that, the Air Vent Valve shall be closed, and the Inlet valve shall be opened to fill the water.

3) Operation of Air Blowers
- ✓ Visually check the condition of air blower for any defects or damage.
- ✓ Set/confirm the selector switch position to select the air blower to be operated on the blower LOP.
- ✓ Set/confirm the selector switch position to select “LOCAL” or “REMOTE” on the blower LOP.
- ✓ Push the lamp test button to ensure all lamps are working.
- ✓ Ensure all the related valves are opened and the Air Scouring Valve (motorized valve) of target RSF is opened.
- ✓ Push the “ON” button start the blower.
- ✓ Check the discharge pressure, current and voltage.
- ✓ Push “OFF” button to stop the blower after operating the set period.
- ✓ Close the Air Scouring Valve.
- ✓ The start and stop time and the above measured values shall be recorded in logbook/mWater form.

5. Air Blower

✓ Daily and periodic inspection shall be performed according to the below table, and the results shall be recorded in logbook/mWater form.

Table: Inspection Points of Air Blower

Points of inspection & maintenance	Frequency
Oil level and its leakage	Daily
Casing/Bearing temperature	
Discharge pressure and current	
Condition of belt (wear etc.)	
Abnormal noise, vibration	
Measurement and correction of belt tension	Monthly
Cleanness of lubricant	
Check the condition of suction filter	
Complete change of lubricant and grease (in accordance with the instruction manual)	Yearly
Check the condition (degree of wear) of oil seal, belt and bearing.	

Table: Troubleshooting of Air Blower

Symptom	Cause	Countermeasure
Abnormal rotation of blower	Power or motor problem	Repair faulty component of power line or motor
	Foreign materials inside blower	Disassemble blower and remove foreign materials
	No oil inside bearing and dust or rust present	Clean and refill oil
	Bearing damaged and rotor in contact with side frame or casing	Replace bearing and repair contacted part
	Fuse blowing during running due to too low fuse rating	Replace with specified fuse
	Tar attached to rotor	Disassemble and clean
Generation of abnormal sounds	Foreign materials inside blower	Disassemble to remove
Generation of abnormal sounds	Loose bolts	Retighten bolts
	Bearing wear	Replace bearing

Symptom	Cause	Countermeasure
	Air leakage	Inspect pipeline system
	Inferior contact or breakage of gear	Adjust or repair gear
	Rotor in contact with casing or another rotor	Disassemble and repair
Severe vibration	Looseness of foundation bolt	Retighten bolts
	Poor installation	Correct installation
	Poor pipe support	Correct pipe support
	Insufficient belt tension	Adjust tension
	Incorrect alignment of centre	Align shaft center
	High discharge pressure	Set to regulated discharge pressure by adjusting discharge valve
High discharge pressure with deficient capacity	Discharge valve closed	Open valve and adjust to regulated pressure
	Pipeline system at discharge side clogged	Clean pipes at discharge side
	Faulty safety valve	Repair or replace safety valve
	Abnormality in pressure gauge	Repair or replace
Low discharge pressure with deficient capacity	Filter at suction side clogged	Clean or replace filter
	Air leakage from discharge tube system	Repair leaking part and replace packing
	Suction tube clogged	Repair leaking part and replace packing
	Incorrect clearance of blower	Correct clearance
	Deficient rotation speed	Adjust belt tension
	Faulty safety valve	Repair or replace safety valve
	Incorrect selection of capacity	Re-select and replace blower
Overload of electric motor and excessive rise of temperature	Discharge pressure higher than specification	Set/adjust discharge pressure to specification
	Excessive or insufficient lubricant	Maintain appropriate level of lubricant

Symptom	Cause	Countermeasure
	Excessive or deficient viscosity of oil due to incorrect selection	Use recommended oil
	Faulty ampere meter	Repair or replace
	Bearing wear	Replace bearing
	Motor worn out	Repair or replace
Oil leakage	Inferior fastening of bolt at oil level gauge	Fasten by binding with Teflon tape
	Wear on oil seal or o-ring	Replace oil seal and O-ring
	Wear on gear case packing	Replace packing
	Oil cock loosened due to vibration	Re-fasten oil injection bore and drain cock
	Excessive oil	Maintain appropriate level in oil level gauge

4) Operation of Backwash Pump

- ✓ Visually check the condition of pumps for any defects or damage.
- ✓ Set/confirm the selector switch position to select the pump to be operated on the LOP.
- ✓ Set/confirm the selector switch position to select “LOCAL” or “REMOTE” on the LOP.
- ✓ Push the lamp test button to ensure all lamps are working.
- ✓ Ensure all the related valves are opened and the Backwash Valve and Backwash Waste Valve (motorized valve) of target RSF are opened.
- ✓ Push the “ON” button start the pump.
- ✓ Check the discharge pressure, current and voltage.
- ✓ Close the Backwash Valve after passing the pre-set period.
- ✓ After the Backwash Valve is fully closed, push “OFF” button to stop the pump.
- ✓ Close the Backwash Waste Valve.
- ✓ The start and stop time and the above measured values shall be recorded in logbook/mWater form.

5) Daily Inspection of Backwash Pump

The following points shall be checked in daily inspection. Inspection results including the measured values shall be recorded in record sheet/mWater form.

- ✓ Abnormal noise and vibration (by hearing/touching)

- ✓ Heat generation of motor (by touching)
- ✓ Discharge pressure, flow rate/amount (by checking pressure gauge, flow meter etc.)
- ✓ Leakage
- ✓ Voltage and current (by checking voltage/ampere meter on the electrical panel)

6) Monthly Inspection of Backwash Pump

The following points shall be checked in monthly inspection. Inspection results including the measured values shall be recorded in record sheet/mWater form.

- ✓ Leakage amount at Grand Packing
  Criterion: q [mL/min] = 0.5×d (mm, shaft dia.)
  In case leakage amount is excess, retightening shall be done.
- ✓ Operation of Discharge Valve

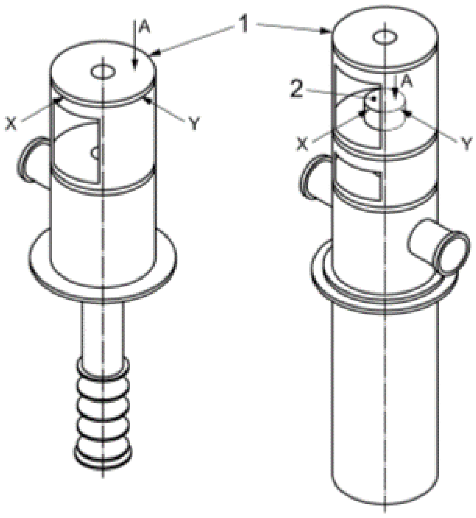
7) Yearly Inspection of Backwash Pump

The following points shall be checked/performed in yearly inspection. Inspection results including the measured values shall be recorded in record sheet/mWater form.

- ✓ Vibration measurement (See the detail procedure as shown below)
- ✓ Insulation measurement
- ✓ Retightening of Anchor Bolts
- ✓ Replace of Grand Packing
  every 1 to 4 years (depending on the condition)
- ✓ Replace of Oil/Grease
  every 1 to 4 years (depending on the condition)
- ✓ Overhaul
  every 4 to 7 years (depending on the condition)

< Procedure of Vibration Measurement >

- ✓ Prepare/set up a vibration meter. (Basically, magnet type sensor shall be used.)
- ✓ Select/decide the measurement locations based on the right figure.
- ✓ Measure/record vibration velocity value [mm/s] at the selected locations with three directions (axial, vertical, horizontal).
- ✓ The results shall be evaluated according to the below table.



Notes)
Location 1: Driver mounting surface/lower motor bearing
Location 2: Pump bearing housing

Zone	Description	Vibration Velocity Limit*	
		≤ 200 kW**	> 200kW**
A	Newly commissioned machine	3.2	4.2
B	Unrestricted long-term operation	5.1	6.1
C	Limited operation	8.5	9.5
D	Risk of damage	> 8.5	> 9.5

Notes)
* *The root-mean-square (r.m.s) value in mm/s*
** *The applicable motor capacity of industrial pump, which is categorized into Category II (pumps for general or less critical application), is above 1 kW.*

8) Inspection and Maintenance of RSF

The following points shall be checked/performed in periodic inspection and maintenance. Inspection results including the measured values shall be recorded in record sheet/mWater form.

Table: Inspection and Maintenance of RSF

Frequency	Points to be checked/performed	Notes
Monthly	Check and confirm time needed for complete cleaning.	Carry out backwashing of the filter and record the values as found. Compare it with the value of previous records

Frequency	Points to be checked/performed	Notes
	Check and confirm the cleaning condition of the filter after backwash.	Make sure that the backwash water is evenly distributed during backwashing. Check at the end of the backwash period whether the water is entirely clean or not and that the top of filter can be seen or not.
	Take a sample of the backwash waste at the end of the backwashing and measure the turbidity of the waste.	If turbidity exceeds 10 NTU adjust/increase the backwash and air scouring time.
	Check and confirm current, oil level, vibration, water leak and oil leak of motorized valves.	Check during operation and backwashing of the filters
	Check the flow rate of air blower and backwash pump during backwashing.	Compare it with the design flow rate and also with the previous values. Adjust the flow by the related valve if required.
Yearly	Drain out the filter and inspect the filter bed condition (mud balls etc.), cracks on walls etc.	Open the related drain valves for an inspection of the filter bed. When mud balls are noticed in an early stage, these shall be removed by scraping the top layer of the bed.
	Cleaning of walls, back wash troughs etc.	Take necessary steps as required.
	Measure the depth of the filter bed and compare it with the previous result. Check whether filter sand exists in the backwash gutter.	If a decrease of depth is found, try to identify the cause: ✓ Check on the loss of sand during backwashing. ✓ Refill the bed with specified filter sand.
Every 5 years	Check the condition of strainers, bottom/structure of the filter.	Repair if any damage is identified.
	Study on filter sand (contamination of filter media, occurrence of mud balls,	Conduct a required analysis such as sieve analysis of the filter sand. Fill with new filter sand if analysis of the

Frequency	Points to be checked/performed	Notes
	effective diameter, uniformity coefficient, filter layer thickness etc.)	filter bed revealed that filter bed does not meet the specifications any more.

6. Electrical Panels

Equipment Required:

1. Digital Insulation / Continuity Testers (KEW 3005A)
2. Power analyzer (KEW 6315)
3. Earth tester (KEW 4105A)
4. AC/DC Digital Clamp Meters (KEW 2046R)
5. Temperature gun (Smart Sensor AT 380)

Safety Measures:

1. Ensure all power sources are de-energized before beginning work
2. Wear personal protective equipment (PPE), including electrical gloves, safety glasses, and a hard hat
3. Follow all manufacturer instructions and safety guidelines when using equipment

Step-by-Step Guide:

1. Visual Inspection:
   - Inspect the electrical panels for any visible signs of damage, including cracks, corrosion, and loose or missing parts.
   - Ensure all labels and identification markers are legible and in good condition.
2. Tightening of Connections:
   - Using a torque screwdriver, tighten all electrical connections in the panels to the manufacturer's recommended specifications.
   - Check for any loose or overheated connections and replace as necessary.
3. Insulation Continuity Test:
   - Using an insulation continuity tester, check the insulation resistance of each circuit within the panel.
   - Record the readings and compare them to previous results to identify any trends or potential issues.
4. Power Quality Analysis:

- Using a power analyzer, monitor the electrical characteristics of the panel and connected equipment.
- Analyze the data to identify any abnormalities or areas for improvement.

5. Temperature Measurement:
    - Using a temperature gun, measure the temperature of the electrical components in the panel, including breakers, fuses, and bus bars.
    - Compare the readings to previous results and manufacturer specifications to identify any potential issues.
6. Cleaning and Lubrication:
    - Clean the interior of the electrical panels using a soft, dry cloth.
    - Apply lubricant to any moving parts, such as hinges and latches, to ensure proper operation.
7. Documentation:
    - Use the forms in mWater Portal and mWater Surveyor to ease the record-keeping
    - Record all maintenance activities and readings
    - Schedule any necessary repairs or replacements based on inspection and testing results.

Schedule: Quarterly

7. Wiring and cables

Equipment required:

1. Digital Insulation / Continuity Testers (KEW 3005A)
2. AC/DC Digital Clamp Meters (KEW 2046R)
3. Non-contact voltage tester (UNI-T UT 12D ROW)
4. Cable ties
5. Cable supports
6. Replacement cables as needed

Safety measures:

1. Ensure power is turned off before any maintenance is performed
2. Use proper personal protective equipment, including gloves and eye protection
3. Follow all manufacturer instructions and safety guidelines when using equipment

Step-by-Step Guide:

1. Visually inspect all wiring and cables for signs of wear, damage, or corrosion. Replace any damaged cables.
2. Check all cable ties and supports for tightness and security. Replace any damaged or missing cable ties or supports.
3. Use the insulation resistance tester to measure the insulation resistance of each cable. Record the readings.
4. Use the digital multimeter to check each cable's voltage and current levels. Record the readings.
5. Verify that all cables are properly grounded.
6. Document any issues found during the inspection and testing and schedule any necessary repairs or replacements.

8. Conduit and Raceways

Equipment Required:

1. Non-contact voltage tester (UNI-T UT 12D ROW)
2. Digital Insulation / Continuity Testers (KEW 3005A)
3. Conduit reamer and cutter
4. Fish tape
5. Wire brush
6. Lubricant for conduits and raceways
7. Replacement conduits and raceways as needed

Safety Measures:

1. Before starting any work, ensure that the power supply to the conduits and raceways is turned off and locked out to prevent accidental start-up.
2. Wear appropriate personal protective equipment (PPE) such as insulated gloves and safety glasses to prevent electric shocks and eye injuries.
3. Use only insulated tools to work on the conduits and raceways.
4. Make sure that the work area is well-lit and free from any hazards such as water or other liquids.

Step-by-Step Guide:

1. Inspect the conduits and raceways for any signs of damage or wear, such as cracks, dents, or rust. Replace any damaged conduits or raceways as needed.
2. Use a non-contact voltage tester to ensure no electrical current flows through the conduits or raceways.

3. Use a conduit reamer and cutter to clean the conduit ends and remove any burrs or sharp edges.
4. Use a wire brush to clean the inside of the conduits and raceways. Make sure to remove any debris or dirt that may cause clogging or damage to the wires.
5. Apply a lubricant to the inside of the conduits and raceways to reduce friction and wear on the wires.
6. Use fish tape to pull new wires through the conduits and raceways as needed.
7. Inspect the raceway supports and hangers for any signs of damage or wear. Replace any damaged or worn-out supports or hangers as needed.
8. Test the continuity of the wires using an insulation continuity tester.
9. Use a temperature gun to check for any hot spots that may indicate loose connections or overloaded circuits.
10. Record all inspections and maintenance activities in a logbook for future reference.

Schedule: Semi-Annually

9. Grounding systems

Equipment:

1. Digital Insulation / Continuity Testers (KEW 3005A)
2. Non-contact voltage tester (UNI-T UT 12D ROW)
3. Earth tester (KEW 4105A)
4. AC/DC Digital Clamp Meters (KEW 2046R)

Safety measures:

- Follow all lockout/tagout procedures to ensure that the grounding system is not energized during maintenance.
- Wear appropriate personal protective equipment (PPE), including gloves and safety glasses, when performing maintenance.
- Do not touch any electrical connections or equipment with bare hands.
- Ensure that the area around the grounding system is clear of debris and other hazards.

Step-by-Step Guide:

1. Inspect the grounding system for any visible damage or signs of wear, such as corroded connections or broken wires.

2. Use the ground resistance tester to measure the resistance of the grounding system. Record the results and compare them to previous measurements to identify any trends or changes.
3. Use the clamp-on ammeter to measure the current flowing through the grounding system. Compare the results to previous measurements to identify any changes.
4. Use the megohmmeter to perform an insulation resistance test on the grounding system. Record the results and compare them to previous measurements to identify any trends or changes.
5. Replace any damaged or worn components as needed.
6. Turn the power back on to the grounding system and verify that it is functioning properly.

Schedule:

- Visual inspection: quarterly
- Testing: annually

10. Electrical motors

Equipment:

1. Power analyzer (KEW 6315)
2. Digital Insulation / Continuity Testers (KEW 3005A)
3. Earth tester (KEW 4105A)
4. AC/DC Digital Clamp Meters (KEW 2046R)
5. Temperature gun (Smart Sensor AT 380)
6. Grease gun
7. Lubricant

Safety Measures:

- Ensure that the motor is disconnected from the power source before conducting any maintenance work.
- Wear appropriate personal protective equipment (PPE), such as gloves and safety glasses.
- Use proper lifting techniques and equipment when handling heavy motor components.

Step-by-Step Guide:

1. Inspect the motor for any signs of wear or damage, such as frayed wires or broken parts.
2. Check the motor's insulation resistance using a Megohmmeter or insulation tester, following the manufacturer's instructions.
3. Use a power analyzer to test the motor's voltage, current, and power consumption, and compare the results to the manufacturer's specifications.
4. Inspect the motor's bearings and lubricate as needed using a grease gun and the appropriate lubricant.
5. Use a multimeter to check the motor's connections and measure the resistance, and repair or replace any damaged or faulty components as needed.
6. Use an infrared thermometer or temperature gun to measure the motor's temperature and ensure it is within the acceptable range.
7. Conduct a visual inspection of the motor's grounding system and use an earth tester to measure the system's resistance to ground.
8. Clean the motor's exterior and surrounding area as needed.
9. Use the forms in mWater Portal and mWater Surveyor to ease the record-keeping
10. Record all maintenance activities and readings
11. Schedule any necessary repairs or replacements based on inspection and testing results.

Schedule:

- Inspect and test the motor quarterly
- Lubricate the motor's bearings quarterly or as recommended by the manufacturer.
- Conduct a full maintenance and inspection of the motor annually.

11. Electrical monitoring and control systems

Equipment Required:

1. Earth tester (KEW 4105A)

Safety Measures:

- Turn off power to the system before starting any maintenance or testing procedures
- Use appropriate personal protective equipment, such as gloves and safety glasses
- Follow lockout/tagout procedures to prevent unexpected power sources from energizing the system
- Use caution when working with live electrical components

Step-by-Step Guide:

1. Inspect all electrical monitoring and control system components for damage or wear, such as frayed wiring or cracked HMI screens, PLCs, HMIs, Sensors, transmitters, Data loggers, Signal conditioners, Network switches and routers
2. Clean any dirty or dusty components using a soft, dry cloth or compressed air.
3. Test sensors and transmitters for accuracy using a signal conditioner and a data logger.
4. Test PLCs and HMIs for proper function using test software or built-in diagnostic tools.
5. Test network switches and routers for proper communication between devices.
6. Test power quality using a power analyzer, checking for voltage drops or other anomalies.
7. Test grounding systems using an earth tester.
8. Replace any worn or damaged components as needed.

Schedule:

- Inspect and clean components monthly
- Testing – Annually
- Replace worn or damaged components as needed

12. Backup power supply (Generator) testing

Tools/ equipment required:

1. AC/DC Digital Clamp Meters (KEW 2046R)
2. Oil
3. Coolant
4. Battery tester

Safety measures:

1. Wear personal protective equipment (PPE), including gloves and safety glasses, to protect against electrical shock and flying debris.
2. Make sure the generator is completely shut off before starting the maintenance.
3. Ensure that the testing area is well-ventilated to avoid the buildup of exhaust fumes.

Step-by-Step Guide:

1. Inspect the emergency generator for any signs of damage.

2. Clean the generator to remove any dirt or debris.
3. Check the oil level and add oil if needed.
4. Check the coolant level and add coolant if needed.
5. Check the battery for any signs of corrosion.
6. Turn on the generator and test its electrical output using a multimeter.
7. Check for leaks or unusual noises coming from the generator.
8. Turn off the generator.

Schedule: Annually

13. Inspect Lighting System

Equipment Required: LED light bulbs, cleaning materials, safety gloves, safety goggles

Safety Measures: Wear appropriate PPE including gloves and goggles when working with lighting systems.

Step-by-Step Guide:

1. Turn off power to the lighting system.
2. Inspect the lighting system and replace any burnt-out bulbs.
3. Clean the light fixtures.
4. Turn the power back on.

Schedule: Monthly

Schedule of electrical activities

Sr. #	Maintenance Activity	Monthly	Quarterly	Semi-annually	Annually
1	Electrical panels (Inspect)	✓			
2	Electrical panels (Test)		✓		
3	Wiring and Cables testing			✓	
4	Conduct and Raceways inspection				
5	Grounding System testing				
6	Electrical Motor (Inspect and test)		✓		
7	Electrical monitoring and control system				✓
8	Backup power supply (Generator) testing				✓
9	Replacement of worn or damaged parts	as needed	as needed	as needed	as needed

Sheet # 1: Preventive Maintenance Record

Preventive Maintenance Record

Approved by : ____________________

Inspected by : ____________________

Site /Pump Name : ____________________

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

Rated Voltage (V) ________ **Rated Current(A)** __________

Efficiency_______ **Power Factor**_________ **RPM**_________

Evaluation Criteria

✓ : Good

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

△ : Need to be improved

— : Not available to be checked

Sr. No.	Inspection Date	Bolt Tightening	Insulation Resistance Test $\geq 1\ M\Omega$												Earth Resistance Test $< 5\ \Omega$		
			U1 - E	V1 - E	W1 - E	U2 - E	V2 - E	W2 - E	U1 - V1	U1 - W1	V1 - W1	U2 - V2	U2 - W2	V2 - W2	Earthing Pit	Motor	MCU
1																	
2																	
3																	

Sr. No.	Inspection Date	Voltage (V) ± 10%			Current (A) ± 5%			Temperature (˚C) ON duration > 30 min, Upto 70˚C					Temperature (˚C) OFF duration > 30 min				
		RY	RB	YB	R	Y	B	MCB	K1	K2	K3	O/L Relay	MCB	K1	K2	K3	O/L Relay
1																	
2																	
2																	

- Remarks -

Sheet # 2: Device Inspection Sheet

Device Inspection Sheet

Approved by :

Inspected by :

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

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

Power Factor_______**RPM**_________

Evaluation Criteria

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

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

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

- Remarks -

Annex 5.1.32 Supplemental materials for tubewell operation at WASA Rawalpindi

- Checklist for Tube Well Operation (Submersible)
- Troubleshooting of Tubewell
- Pump Selection

ٹیوب ویل کو چلانے کے لیے چیک لسٹ (Submersible)

Tube well Number:____________	تاریخ (Month_________________, Year_________)																						Shift ____________								
Parameters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Before Operation/ آپریشن سے پہلے																															
پینل پر بتیاں (lights) کام کر رہی ہیں																															
کوئی بھی ریلے (relay) بائی پاس نہیں ہے																															
تار کنکشن درست ہیں																															
وولٹیج چیک کریں اور حد (limit) کے اندر ہے یعنی 440V-360																															
During Operation/ آپریشن کے دوران																															
والو / valve کھلا ہے-																															
پانی کی (leakage) نہیں ہو رہا																															
وولٹیج چیک کریں اور حد (limit) کے اندر ہے یعنی 440V-360																															
تینوں فیز پر کرنٹ ریڈنگ کرنٹ سیٹ سے کم ہے (I rated = ________A)																															
بجلی کا میٹر (electric meter) کام کر رہا ہے																															
پریشر (pressure) معمول کی حد میں ہے																															
کلورینیٹر (chlorinator) کام کر رہا ہے																															
موٹر کو (rest time) دیا ہے																															
سیفٹی کی ہے / ٹھیک ہے																															
Record Keeping/ ریکارڈ کیپنگ																															
ڈیٹا لاگ بک (log book) میں اپ ڈیٹ کیا گیا ہے																															

TROUBLESHOOTING AT TUBE WELL

O&M (operation and maintenance) manuals are supplied with all control panels, pumps, motors etc., and should be used as a guide for all troubleshooting. Those manuals are specifically made for individual equipment and are generally sufficient for any or all problems which may be encountered.

This document is for training purposes only and shall provide some general information about the O&M of a Motor Control Panel at the Tube well station. You are strongly recommended to use the O&M manual of that particular facility to do some troubleshooting.

PRECAUTIONS!!!

- Anyone testing electrical systems should take precautions to ensure the safety of themselves, others and equipment under test.
- Always assume that all wiring and parts are energized.
- Even though connections to the panel have been broken, it is possible that other circuits are still “hot/ energized”.
- All work on the panel should be done by a qualified technician.

Symptoms	Cause	Countermeasures
Pump does not start	Check for the incoming power	If there is no or improper incoming power then contact the relevant Distribution Company (DISCO) for the power to resume.
	Check for the fault lamps	Find the cause and do the countermeasure as recommended below as per the relevant issue.
Lights on the Panel are not working	Power supply issue	Wait for the power supply to resume.
	Light is burnt out	Replace the light.
	Loose connections	Tight the connection.
	Wire is damaged	Repair or replace the damaged wire.
Lights flickering or dim	Poor connections	Check and tighten all electrical connections.
	Voltage fluctuations	Use a multimeter to measure the voltage and address fluctuations.
	Defective light bulbs or indicators	Replace any faulty light bulbs or indicators.
Circuit Breaker is tripping	Short circuit	Look for burn mark, loose connection or damaged components. Replace the damaged component.
	Operating current is slightly high	Check the section “Motor is overheating”.
	Abnormal voltage	Check for unstable voltage conditions and address any issues with the power supply.
	Circuit breaker is undersized or damaged	Replace the circuit breaker.
	Ground faults	Perform insulation resistance tests to identify and address ground faults.
Overload Relay is tripping	Mechanical issues with the motor	Check for any mechanical problems with the motor, such as misalignment, bearing issues, impeller being clogged, shaft being stuck or coupling problems. Address any mechanical issues found.
	Abnormal voltage	Check for voltage fluctuations or imbalances in the electrical supply. Address any issues with the power supply company.
	Motor windings are short	Rewind the motor and do the in-house testing including (IR Test, Resistance test, No-load test and On-load test).

		If repairing doesn't work then replace the motor.
	Relay is malfunction	Swap the relay with the recommended type and specifications.
	Poor ventilation or cooling of the motor	Verify that the motor is adequately ventilated and cooled. Ensure that cooling fans are working correctly and that the motor is not overheating.
Over/ Under Voltage relay is tripping	Voltage is more than 440V or less than 360	Transformer rating or tapping issue, since it is at the power supply end so contact IESCO
	Relay is malfunction	Swap the relay with the recommended type and specifications.
	Wiring or connection issues	Inspect and tighten loose connections. Perform a visual inspection of wiring and connections. Repair or replace damaged wiring and conduct continuity tests on relevant wiring.
	Motor is overload or damaged	Inspect motor insulation for faults. Verify that the motor insulation is in good condition.
Smoke, smell or discoloring of wire	Overheating in the panel	Look for the cause of overheating which may be resolved by: tightening the loose connections, replacing the undersized wires, changing the damaged contactor, relay, breaker or other components
	Short-circuit	Replace damaged components and ensure proper insulation.
	Insufficient ventilation or cooling	Ensure proper ventilation around the panel. Install additional cooling fans or ventilation as needed. Also, verify the ambient temperature of the area.
Water-Level-Switch is tripping	Water level is too low	Deep dig the issue and use a suitable countermeasure, for example, lower the pump or use a smaller pump etc.
	Loose connection/ damaged wire	Repair or replace the cables/ wires.
	Water-Level-Switch is malfunction	Test the water level switch and if it isn't operating properly, replace it.
Voltage is unstable	Voltage fluctuations or imbalances when the motor is switched OFF	Check the main wire and any abnormality in the transformer and energy meter. Address any issues with the power supply company.

	Voltage fluctuations or imbalances when the motor is switched ON	Check the electrical connections at the terminals of equipment, cable insulation and insulation of the motor.
Motor is overheating	Check for adequate water flow and cooling around the motor	Do the cooling arrangements as per the recommendation of the manufacturer.
	Ensure proper voltage and current levels	Check for the imbalance voltages and currents and resolve the issue.
	Blockage in the mechanical section	Check for any mechanical problems with the motor, such as misalignment, bearing issues, impeller being clogged, shaft being stuck or coupling problems. Address any mechanical issues found.
	Rewound motor is installed	Rewinding normally causes the change in the drawing current so check the drawing current and contact the CONTRACTOR if the value is more than the rated value
Too much noise and/or vibration	Check for loose or misaligned parts within the pump assembly	
	Inspect the impeller and casing for debris or damage.	
Leakage in pipe		
Valves not working	Valve deteriorated	
Leakage in valve	Gland packing issue	
	Gas kit issue	
Leakage in joints	Gas kit issue	
Leakage from pump	Gland packing issue	
Pressure is too low	Check for clogs or debris in the pump intake or impeller	Remove debris and clean components.
	Check for leaks in the system	
Pressure is too high	Check the valve	
Water flowrate is too low	Impeller is stuck	
	Check the valve	
	Water level is too low	
Water flow rate is too high	Check the valve	
	Water level is too high	
Chlorinator is not working	Check the voltages in the switch board and connections of shoe	

SELECTION OF PUMP

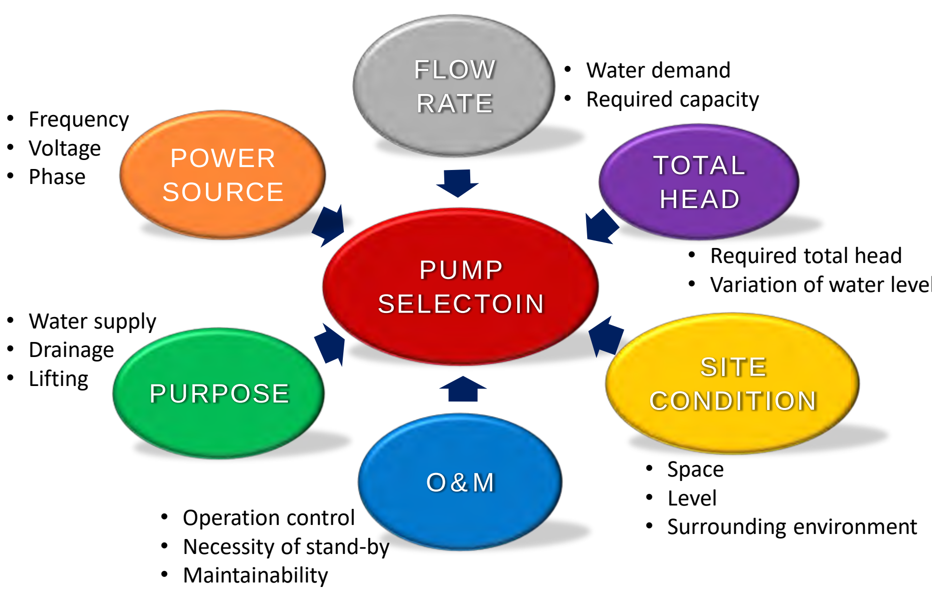
Table of Contents

Importance of Pump Selection

Pump should be selected properly considering the purpose and condition. Wrong selection will cause…

- ✓ **Short Lifecycle**
- ✓ **Energy Loss**
- ✓ **Operational Downtime**
- ✓ **High O&M Cost**

Factors for Pump Selection



Parameters for Pump Selection

- ✓ **Pump Type [Centrifugal, Mixed-flow, Axial-flow, Submersible, Horizontal/Vertical]**
- ✓ **Flow Rate Q [cusec, m^3/h]**
- ✓ **Total Head H [m, ft]**
- ✓ **Discharge Diameter [mm]**
- ✓ **Motor Output [kW, HP]**
- ✓ **Pump Efficiency [%]**
- ✓ Others: Quantity, Liquid Type, Material, Paint, Installation/Maintenance Space etc.

Pump Types and Its Characteristics

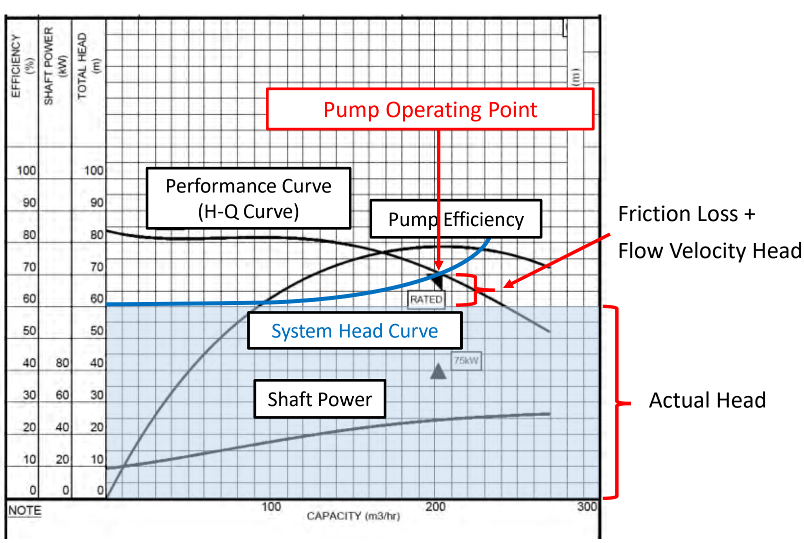
PUMP
- **Turbo Type Pumps**
  - **Centrifugal Pumps**
    - **Volute Pump**
    - Diffuser Pump
  - **Mixed Flow Pumps**
    - **Volute Type Mixed Flow Pump**
    - **Mixed Flow Pump**
  - Axial Flow Pumps
- Displacement Pumps
- Special Type Pumps



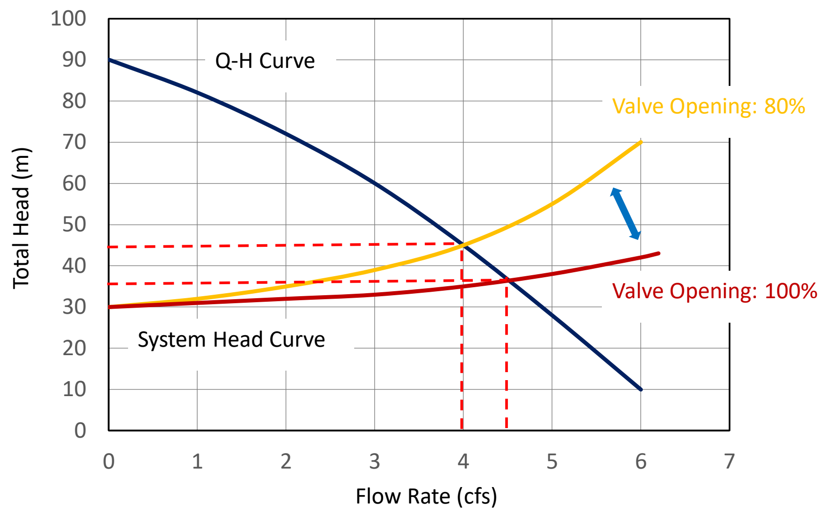

Pump Types and Its Characteristics

	Volute Pump	Volute Type Mixed Flow Pump	Mixed Flow Pump
Outline	・Total Head (m): 10 to 800 ・Dia. (mm): 40 to 2,000 ・Mainly for Intake, Transmission & Distribution of Water Supply	・Total Head (m): 2.5 to 30 ・Dia. (mm): 150 to 5,000 ・Mainly for Storm Drainage & Disposal of Sewerage	・Total Head (m): 2.5 to 60 ・Dia. (mm): 150 to 5,000 ・Mainly for Intake of Water Supply, Storm Drainage & Disposal of Sewerage
Merits	・Good Suction Performance ・High Pump Efficiency in a wide range of discharge	・Lighter Weight than Volute Pump ・Less Installation Area	
Demerits	・Heavy Weight ・Large Installation Area	・Less Pump Efficiency than Volute Pump ・Less Suction Performance than Volute Pump	

Understanding of Pump Performance Curve (1)



Understanding of Pump Performance Curve (2)



How to Decide/Calculate Important Parameters

1. Flow Rate for Water Supply (Distribution)

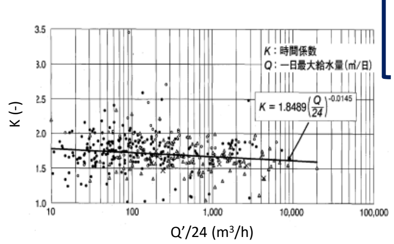
Required **Flow Rate (Q)** of pump shall meet the **Design Maximum Hourly Supply** in the target service area. **Q** can be calculated/decided by the following formula.

Q = K x Q'/24

Q = Flow Rate/Design Maximum Hourly Supply (m^3/hour)

K = Time Factor (-)

Q' = Design Maximum Daily Supply (m^3/day)



Reference: Design Criteria for Water Supply Facilities (JWWA)

- *Q' is the maximum water demand in the target service area. Basically, this value is calculated/set in a master plan or preliminary/basic design.*
- *K is determined considering the peak hour of water consumption.*

How to Decide/Calculate Important Parameters

2. Flow Rate for Disposal Station

Required **Flow Rate (Q)** of pump shall be meet the **Peak Wet Weather Flow (PWWF)** in the target area.

PWWF is the highest observed hourly flow* in a rainy/storm day.

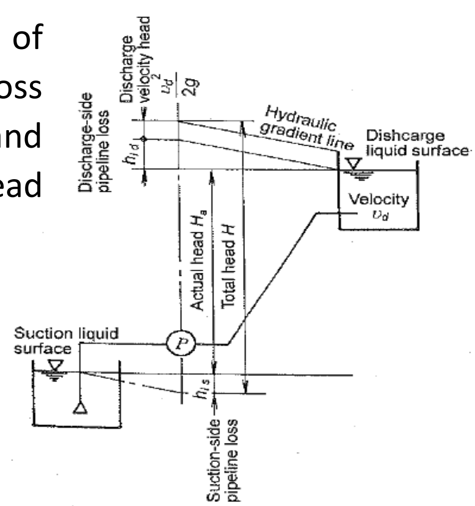
** WASAs have to consider both sewage and storm (rain) water.*

How to Decide/Calculate Important Parameters

3. Total Head for Vertical Pump

Total Head (H) is sum of actual head (Ha), head loss of discharge pipe (hdp) and discharge flow velocity head ($vd^2/2g$).

$H = Ha + hdp + vd^2/2g$

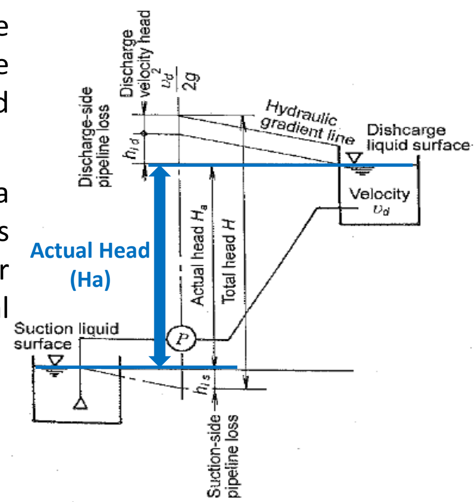


How to Decide/Calculate Important Parameters

3. Total Head for Vertical Pump

Actual Head (Ha) is the difference between discharge fluid level and suction fluid level.

It is necessary to consider a variation of water level, such as a decreasing groundwater level, for determination of total head.



How to Decide/Calculate Important Parameters

3. Total Head for Vertical Pump

Head Loss of Discharge Pipe (hdp) can be generally calculated by Hazen-Williams formula.

This formula is applicable for relatively long pipeline such as distribution pipeline of water supply.

$$hdp = \frac{10.666 \times Q^{1.85} \times L}{C^{1.85} \times D^{4.87}}$$

- Q = Discharge Quantity (m^3/sec)
- C = Flow Coefficient (-)
  C=110 is applied for mortar lining iron pipe, coated steel pipe and vinyl chloride pipe including bends.
- D = Pipe Diameter (m)
- L = Total length of pipeline (m)

How to Decide/Calculate Important Parameters

3. Total Head for Vertical Pump

Discharge Flow Velocity Head ($vd^2/2g$) depends on the flow velocity at the end of discharge pipe (**vd**).

vd can be calculated by the following formula.

$$vd\ [m/s] = Q / A$$
$$= Q / (3.14 \times D^2/4)$$

Q = Discharge Quantity (m^3/sec)
A = Sectional Area of Discharge Pipe (m^2)
D = Pipe Diameter (m)
g = Gravity Acceleration (m/s^2) : 9.8

How to Decide/Calculate Important Parameters

4. Discharge Diameter of Pump

Discharge Diameter of Pump (D) depends on the discharge quantity (**Q**).

D can be calculated by the following formula.

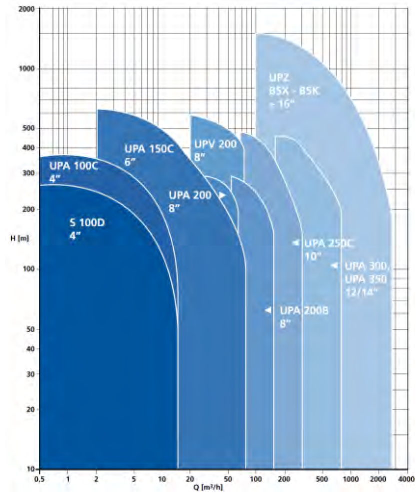
$$\underline{D\ [mm] = 146 \times \sqrt{(Q/V)}}$$

Q = Discharge Quantity (m^3/min)
V = Flow Velocity (m/s)
Generally, 1.5 to 3.0 m/s is applied.

How to Decide/Calculate Important Parameters

4. Discharge Diameter of Pump

After getting the calculated value, proper value shall be confirmed/determined based on manufacturer's catalog.



Reference: Selection Chart of Well Pump (KSB)

How to Decide/Calculate Important Parameters

5. Motor Output

Motor Output (P) can be calculated by the following formula.

$$P\,[kW] = \frac{\rho \times g \times Q \times H}{60{,}000 \times \eta p \times \eta g} \times (1 + \alpha)$$

ρ = Liquid Density (kg/m^3) : *1,000*
g = Gravity Acceleration (m/s^2) : *9.8*
Q = Discharge Quantity (m^3/min)
H = Total Head (m)
ηp = Pump Efficiency (-) : Explained later
ηg = Transfer Efficiency (-) : Explained later
α = Allowance (-) : *Generally, 0.1 to 0.2*

How to Decide/Calculate Important Parameters

5. Motor Output

Pump Efficiency (ηp) is the ratio of Liquid Power (Lw) to Shaft Power (L).

- Liquid Power (Lw) is the available energy of pump which is given to liquid per unit time.

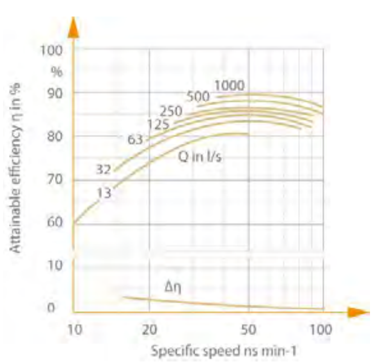
$$Lw\,[kW] = \frac{\rho \times g \times Q \times H}{60{,}000}$$

- Shaft Power (L) is the power which is transmitted to pump shaft by electrical motor.

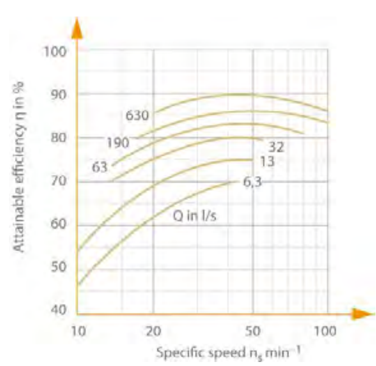
How to Decide/Calculate Important Parameters

5. Motor Output

Typical **Pump Efficiency (ηp)** is shown in the below figures.



< Single-stage Volute Pump >



< Multistage Volute Pump >

Reference: KSB Website

How to Decide/Calculate Important Parameters

5. Motor Output

The following values of **Pump Efficiency** and **Transfer Efficiency** are applied for motor output calculation.

- **Pump Efficiency (ηp)**:

  Generally, **0.7 to 0.9 (70 to 90 %)**

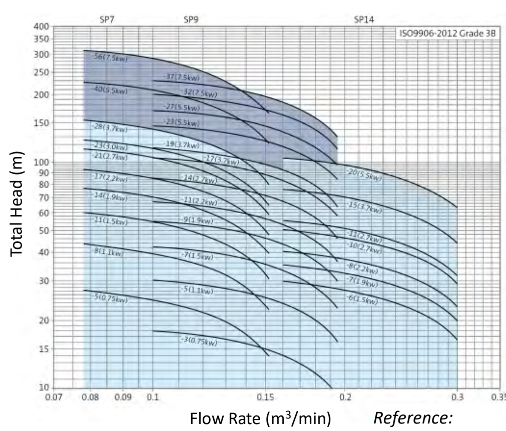
- **Transfer Efficiency (ηg)**:

  Generally, **1.0** (in case of direct coupling)

How to Decide/Calculate Important Parameters

5. Motor Output

After getting the calculated value, proper value shall be confirmed/determined based on manufacturer's catalog.



Reference:
Selection Chart of Well Pump (GRUNDFOS)

Protection of Pump

Screen shall be selected and installed properly to avoid entering foreign materials into pumps.

	Coarse Screen	Fine Screen
Outline	To remove large foreign materials	To remove small foreign materials
Scale Spacing	50 to 150 mm	25 to 50 mm (1/10 to 1/30 of pump discharge diameter)
Operation	Manual	Manual or Automatic

Protection of Pump

The following fine screens are used by WASAs.

Bar Screen (Manual)

Bar Screen with Rake & Backet (Automatic)

Bar Screen with Rake (Automatic)

Major Issues and Troubles

Case-1. Clogging, Abrasion or Damage due to Sucking Foreign Materials

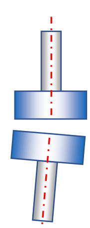
A piece of cloth

Plastic Bags

Too much garbage is flowing into Disposal Station !!

Major Issues and Troubles

Case-2. Vibration due to Misalignment



Major Issues and Troubles

Case-3. Vibration due to Insufficient Strength of Pump Base

Major Issues and Troubles

Case-4. Decreasing of Pump Flow due to Groundwater Level Lowering

Exercise

Annex 5.1.33 MM on 2nd TAC held on 10th June, 2022

MINUTES OF MEETING

2nd Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"

Lahore, June 10th, 2022.

Mr. M. Ghufran,
Managing Director
WASA Lahore
14/06/22

佐藤 伸幸
Dr. Nobuyuki Sato,
Chief Technical Advisor,
JICA Expert Team,

MINUTES OF MEETING		
Subject:	2nd Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"	
Date:	Friday, 10th June, 2022	Time: 10:00 am
Venue:	Head office, WASA Lahore.	
Participants:	Pakistani side • Mr. M. Ghufran, Managing Director WASA Lahore (Chairperson) • Mr. Riaz Mujtaba, Director Training, WASA Lahore (Secretary TAC) • Ms. Zseema Aman, DD Training WASA Lahore • Mr. Absul Samad, AD Training WASA Lahore • Mr. Jawad Shahid, Vice Principal, E&M Specialist, Al-Jazari Academy • Mr. Muhammad Irfan, Water and Sewerage Specialist, Al-Jazari Academy • Mr. M. Nadeem, DD WASA Multan/ WASA Coordinator (Online) • Mr. Khurram Nabeel Butt, DD WASA Gujranwala/ WASA Coordinator (Online) • Mr. Roohan Javaid, DD WASA Faisalabad/ WASA Coordinators (Online) • Mr. Noor Rabbani, AD P&D WASA Rawalpindi/ WASA Trainer (Online) Japanese side • Dr. Nobuyuki Sato, Chief Advisor, JICA Experts Team • Ms. Mikiko Azuma, JICA Experts Team (Online) • Mr. Tatsuo Tomidokoro, JICA Experts Team • Mr. Yusaku Numajiri, JICA Experts Team • Mr. Kazuhiro Kayanoma, JICA Experts Team (Online) • Mr. Muhammad Hafeez, JICA Coordinator	
Summary	Technical Advisory Committee for the project has approved the training schedules and contents for "O&M on Sewerage and Drainage" and "O&M on Mechanical and Electrical Equipment", which will be implemented from 13th to 17th June, 2022.	

DISCUSSION AND DECISIONS
The Meeting started with opening remarks from Mr. M. Ghufran, MD WASA Lahore.

- Dr Sato, Chief Advisor, JICA Experts Team, explained that the schedule and content of the trainings will be flexibly adjusted due to high temperature and load shedding.
- Mr. Muhammad Irfan, Water and Sewerage Specialist, Al-Jazari Academy, explained the schedule and contents of the training "O&M on Sewerage and Drainage" (see Attachment 1).
- Mr. Jawad Shahid, Vice Principal, E&M Specialist, Al-Jazari Academy, explained the schedule and contents of the training "O&M on Mechanical and Electrical Equipment" (see Attachment 2).

After that explanation, there was a question from WASA Gujranwala. The question was whether a topic of a motor for pump is included or not. Mr. Jawad Shahid answered that it is included.

Decisions:

The training schedules and contents for "O&M on Sewerage and Drainage" and "O&M on Mechanical and Electrical Equipment" were approved.

The meeting ended with note of thanks from the Chair.

Attachment 1

Training schedules for "O&M on Sewerage and Drainage"

JICA

ALJAZARI ACADEMY

Operation & Maintenance of Sewerage and Drainage System
Training Schedule (JICA Phase-II) 2022

Sr. No.	Day and Date	Module Name	Session-1			Tea 10:45 am-11:00 am	Session-2			Lunch 1:15 pm-2:00 pm	Session-3	
			1st Lecture		2nd Lecture		3rd Lecture		4th Lecture		5th Lecture	6th Lecture
			09:00 am-9:15 am	9:15 am-10:00 am	10:00 am-10:45 am		11:00 am-11:45 am	11:45 am-12:15 pm	12:15 am-1:15 pm		2:00 pm-3:30 pm	3:30 pm-4:00 pm
1	Monday June 13, 2022	Module 01 **Cleaning of Sewerage & Drainage Pipelines**	• Welcoming Remarks • Participant Introduction • Course Overview • Training Expectations	• Removal of Blockages in Sewer Lines • Latest Cleaning Techniques of Sewerage & Drainage System	• Introduction to Sewer Camera (Parts + Working) (Demonstration) • Repair & Maintenance of Sewerage & Drainage Pipelines	**Tea Break (As per Site Visit Situation)**	**FIELD WORK** **(Unpack-Assemble-Install-Use-Packing)** • Manhole & Sewer & Inspection with Camera			**Lunch & Prayer Break (As per Site Visit Situation)**	**FIELD WORK** • Manhole & Sewer & Inspection with Camera (Evalution of Manhole & Sewer)	• Quick Win Measures (QWMs) • Conclusion on Day's Activities
2	Tuesday Jun 14, 2022	Module 02 **Flow Measurement of Open Channels**	• Recap of Previous Day Activities	• Objectives • Types of Drains • Methods & Formulae	**FIELD WORK** **(Unpack-Assemble-Install-Use-Packing)** • Velocity Meter		**FIELD WORK** **(Unpack-Assemble-Install-Use-Packing)** • Velocity Meter				**FIELD WORK** • Measuring Flow Velocity in Open Chanel • Calculation of Flow Rate	• Quick Win Measures (QWMs) • Conclusion on Day's Activities
3	Wednesday Jun 15, 2022	Module 3 & 4 **Wastewater Treatment (WWT)**	• Basics of WWT • WWT Technologies	• Rapid Testing of Wastewater Samples with Kits (BOD, pH, DO)	• How to Clean & Maintain Ponds of WWTP		• Fianacial Comparison of Various Technology w.r.t. CAPEX & OPEX				• Most Suitable Technology	• Reflections • Group Picture • Certificates

Academy Team: Engr. Muhammad Irfan, Engr. Syed Fahad Hussain, Engr. Haris Bin Khawar

42

ALJAZARI ACADEMY

Attachment 2

Training schedules for "O&M on Mechanical and Electrical Equipment"

Time Schedule of O&M of Mechanical Equipment Training (Draft)

1st Day: 16th June (Thu)		
Time	**Activity**	**Notes**
9:30 - 9:45	**Introduction**	
	Orientation	
9:45 - 11:00	**Basics of Pump**	Exercise by using the pump model
	・Typical components of pump facility.	
	・Hydraulic parameters (Flow Rate, Discharge Pressure, Total Head) ・Electrical parameters (Voltage, Ampere)	Trainees will check/measure each parameter by themselves.
	・Parallel & series pump operation	
	・Pump performance curve (Relationship between flow and discharge pressure) ・Relationship between flow and current	Trainees will demonstrate each items by using the pump model.
11:00 - 12:00	**Understanding of Ultrasonic Flow Meter**	Exercise by using the pump model
	・What will happen if we don't follow 10d recommendation ?	
	・What will happen if the setting value of pipe thickness is wrong ? ・What will happen if the setting value of pipe diameter is wrong ?	Trainees will demonstrate each items by using a ultrasonic flow meter on the pump model.
	・What will happen if the setting of pipe material is wrong ?	
	・What will happen if the installation distance of sensor is not proper ?	
12:00 - 13:00	**Basics of Asset Lifecycle Analysis with Examples**	Lecture with showing good practices in France
13:00 - 14:00	*Lunch & Prayer Break*	
14:00 - 15:00	**Data Analysis** ・Making a pump performance curve by Excel.	Exercise by using Excel

2nd Day: 17th June (Fri)		
Time	**Activity**	**Notes**
09:00-10:00	Vibration Analysis and its importance Understanding of Vibration Meter	
	Use of Vibration Meter • Installation of Vibration Meters on Machinery	Vibration Analysis field activity on Disposal Station
10:00 - 12:30	**Site Visit to WASA-L Disposal Station** ・Understanding of actual O&M activities ・Understanding of vibration meter ・Vibration measurement and filling the record sheet	Practical Training at the site
12:30 - 14:00	*Move to AJWA, Lunch & Prayer Break*	
14:00 - 15:00	**Preparation of Maintenance Plan for Pump Facilities**	
	Q&A	
15:00 - 15:15	**Closing**	

Annex 5.1.34 MM on 3rd TAC held on 14th October, 2022

MINUTES OF MEETING

3rd Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"

Lahore, October 14th, 2022.

Mr. Abdul Latif
Deputy Managing Director (O&M)
WASA Lahore

佐藤伸幸
Dr. Nobuyuki Sato,
Chief Technical Advisor,
JICA Expert Team,

MINUTES OF MEETING		
Subject:	3rd Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"	
Date:	Friday, October 14, 2022	Time: 03:00 pm
Venue:	Head office, WASA Lahore.	
Participants:	Pakistani side • Mr. Abdul Latif, Deputy Managing Director, WASA Lahore (Chairperson) • Mr. Riaz Mujtaba, Director Training, WASA Lahore (Secretary TAC) • Mr. Hisham Pervaiz Vasser, Director, WASA Lahore • Mr. Jawad Shahid, Vice Principal, E&M Specialist, Al-Jazari Academy • Ms. Rebia Suhail, Sr. Instructor, Al-Jazari Academy • Mr. Muhammad Hafeez, JICA Coordinator • Mr. Zain Hassan, JICA Coordinator • Mr. M. Nadeem, DD WASA Multan/ WASA Coordinator (Online) • Mr. Khurram Nabeel Butt, DD WASA Gujranwala/ WASA Coordinator (Online) • Mr. Roohan Javaid, Director WASA Faisalabad/ WASA Coordinator (Online) • Mr. Aziz Ullah Khan, DD WASA Rawalpindi/ WASA Coordinator (Online) Japanese side • Dr. Nobuyuki Sato, Chief Advisor, JICA Experts Team • Mr. Tatsuo Tomidokoro, JICA Experts Team • Mr. Hiroyuki Tabusa, JICA Experts Team • Mr. Kazuhiro Kayanoma, JICA Experts Team	
Decisions	1. Technical Advisory Committee approved the schedule of professional training for "Leakage Control, Plumbing and Pipe Replacement Plan" from 25th to 27th of October, 2022 along with the recommended improvements in the content. 2. Technical Advisory Committee approved the schedule and content of professional training for "O&M of Mechanical and Electrical Equipment" from 8th to 10th of November, 2022. 3. Committee also accepted: i. Practical activity approach for "Professional Training" on above approved two courses.	

	ii. The role of "WASA coordinators meetings" includes a part of PCC from upcoming PCC iii. The discussion for collaboration work between WASA and AJWA starts from the upcoming TAC

DISCUSSIONS

The Meeting started with opening remarks from the chair.

- The Chief Advisor, JICA Experts Team, explained the agenda. The main items presented by him included:
  1. Approval of professional training for "Leakage Control, Plumbing and Pipe Replacement Plan" from 25th to 27th of October, 2022.
  2. Approval of professional training for "O&M of Mechanical and Electrical Equipment" from 8th to 10th of November, 2022
  3. Proposal of WASA Coordinators Meeting
  4. Proposal for collaboration work between WASA Lahore and AJWA
- For the training at AJWA, Chief Advisor emphasized on an importance of activities in the training. He explained that the lectures and videos put the trainees in the passive learning mode. The approach by JET is to maximize the outcome of the training by the trainings in the constructive and interactive learning mode.
- Ms. Rebia explained the time plan and activity-outcomes of the training course, "Leakage Control, Plumbing and Pipe Replacement Plan". Comments from the participants included:
  i. Mr. Hisham told that nomenclature and terminologies in the course should be revised as per understanding of WASA staff. He requested a few modifications in the models and to update the content as per the daily work of WASA staff. The content should reflect daily work of Assistant Directors and Sub Engineers. He further requested to explain the role of models for the training.
  ii. Mr. Roohan requested to make the content more descriptive. He was of the view that the pictures only were not enough for the understanding.
  iii. Mr. Khurram informed that they wanted to learn the specifications of water meters, useful in WASA system in this course.
  iv. Dr. Sato explained the activity by NRW model. The details are as follows.
  i) The flow between a) a bulk meter and consumer meters, and b) a ultrasonic flow meter and a water meter could be compared.
  ii) The terminologies would be updated as per understanding of WASAs.

iii) The supporting documents can be shared to the participants during training.

iv) Water meters are explained with disassembled actual material for the type of single jet, multi jet, and rotary piston type.

- Mr. Jawad explained the time plan and activity-outcomes of the training course, "O&M of Mechanical and Electrical Equipment". Comments from the participants included:
  i. Mr. Hisham told that the course content was fine but the main role of the officers to supervise and ensure proper implementation of the maintenance plan should be included.
  ii. Mr. Roohan suggested to add the design of the motor control panel. In addition, he suggested to add the sizing of the cables, circuit breaker, magnetic contactor, protection relays and other component.
  iii. Mr. Khurram requested to add the maintenance of transformer.
  iv. Mr. Jawad agreed to add the preventive maintenance plan and electrical panel design as recommended.
  v. Dr. Sato explained that in TNA the course topics were prioritized. Transformer was not concluded as the high priority among the requested topics as per discussion with WASAs and an evaluation be JET. So, it would be difficult to include the transformers at this stage.
- Mr. Jawad recommended to have a working group for each course so the development of course content would be improved. He was of the view that meetings among JICA Expert, counterpart from AJWA and master trainer of WASAs should be organized to prepare the content for every course.
- Chair approved the both professional trainings along with the recommended changes by the forum and recommended further discussions on the other agenda items by Chief Advisor.

Annex 5.1.35 MM on 4th TAC held on 2nd November, 2022

MINUTES OF MEETING

4th Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"

Lahore, November 2nd, 2022.

Mr. Abdul Latif
Deputy Managing Director
WASA Lahore

佐藤 伸幸

Dr. Nobuyuki Sato,
Chief Technical Advisor,
JICA Expert Team,

MINUTES OF MEETING		
Subject:	[4th] Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"	
Date:	Wednesday, November [2nd], 2022	Time: 03:00 pm
Venue:	Head office, WASA Lahore.	
Participants:	Pakistani side • Mr. Abdul Latif, Deputy Managing Director, WASA Lahore (Chairperson) • Mr. Souman Khalid, Deputy Secretory, HUD&PHED • Mr. Riaz Mujtaba, Director Training, WASA Lahore (Secretary TAC) • Mr. Hisham Pervaiz Vasser, Project Director Planning (LWWMP) / Focal Person (Foreign Trainings), WASA Lahore • Ms. Zaeema Aman, Deputy Director Training, WASA Lahore • Mr. Jawad Shahid, Vice Principal, E&M Specialist, Al-Jazari Academy • Mr. Fahad Hussain, Instructor, Al-Jazari Academy • Ms. Rebia Suhail, Sr. Instructor, Al-Jazari Academy • Mr. Muhammad Hafeez, JICA Coordinator • Mr. Wajih-Ud-Din, JICA Coordinator • Mr. M. Nadeem, DD WASA Multan/ WASA Coordinator (Online) • Mr. Khurram Nabeel Butt, DD WASA Gujranwala/ WASA Coordinator (Online) • Mr. Roohan Javaid, Director WASA Faisalabad/ WASA Coordinator (Online) • Mr. Aziz Ullah Khan, DD WASA Rawalpindi/ WASA Coordinator (Online) Japanese side • Dr. Nobuyuki Sato, Chief Advisor, JICA Experts Team • Mr. Tatsuo Tomidokoro, JICA Experts Team • Mr. Kazuhiro Kayanoma, JICA Experts Team • Mr. Hiroyuki Tabusa, JICA Experts Team (Online)	
Decisions	1. Technical Advisory Committee approved the schedule and content of professional training for "O&M on Sewerage and Drainage" from 22nd to 24th of November, 2022. 2. Committee also accepted:	

	i) practical activity approach for "Professional Training" on above approved course. ii) an improvement of professional training, "Leakage Control, Plumbing and Pipe Replacement Plan" conducted from 25th to 27th October, 2022. iii) guest lecturers by experience staff from WASAs for "Professional Training"

DISCUSSIONS

The Meeting started with opening remarks from the chair.

- The Chief Advisor, JICA Experts Team, explained the agenda and practical activity approach for "O&M on Sewerage and Drainage".
- Mr. Fahad explained the time plan and learning-outcomes of the training course, "O&M on Sewerage and Drainage". Comments from the participants included:
    i. Ms. Zaeema asked about water quality test. She was of the view that it takes 5 days to obtain a value of BOD normally. Dr. Sato explained that those kits can give an instant value in a short time, and give tentative values of water quality.
    ii. Mr. Souman and Mr. Rohan requested to know the experience of the trainers. He is of the view that AJWA should invite the retired staff from WASAs having relevant experiences to enhance the quality of their trainings by using their knowledge and experience.
    iii. Mr. Sanwal (WASA Faisalabad) and Mr. Abdul Moeed (WASA Multan) requested to add software training such as sewer-cad, mWater, and GIS in sewerage sector. Mr. Rohan requested for re-modelling, hydraulic modelling, separate and combined system of sewerage and drains. Mr. Hisham highlighted mWater is capable to develop database of sewerage related complaints. Dr. Sato explained that the training topics were decided according to the training needs assessment in the first year. But we can discuss it accordingly.
    iv. Mr. Hisham asked the details of public awareness included in "O&M on Sewerage and Drainage". He was of the view that sewer camera can be very useful to monitor pipe condition and locating buried manholes and branches. Mr. Fahad explained that
        a) school children would be invited,
        b) sewer camera would be used to observe inside sewer pipe,
        c) children can watch inside sewer pipe through big screens,
        d) it is explained for generation of overflow by garbage, etc.

- Miss Rebia explained the feedback of professional training "Leakage Control, Plumbing and Pipe Replacement Plan" from 25th to 27th October, 2022. She informed how the model was improved and the positive feedback from the trainees. In addition, her recommendation was to involve the senior staff of WASAs from the course development stage. There was no participation from WASA Multan. WASA Multan will find out the reason of it.
- Mr. Jawad requested the chair to know the status issuance of the funds in this fiscal year and involvement of the experienced staff from WASAs to the professional trainings.

Annex 5.1.36 MM on 5th TAC held on 21st December, 2022

MINUTES OF MEETING

5th Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"

Lahore, December 21st, 2022.

Mr. Mian Muhammad Munir,	佐藤伸幸
Deputy Managing Director (F, A&R)	**Dr. Nobuyuki Sato,**
WASA Lahore	Chief Technical Advisor,
	JICA Expert Team,

MINUTES OF MEETING		
Subject:	5th Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"	
Date:	Wednesday, December 21, 2022	Time: 02:00 pm
Venue:	Head office, WASA Lahore.	
Participants :	Pakistani side • Mr. Hisham Pervaiz Vasser, Project Director (LWWMP) / Focal Person (Foreign Trainings), WASA Lahore *(Chairperson on behalf on DMD(F,A&R), WASA Lahore)* • Mr. Souman Khalid, Deputy Secretory (UD), HUD&PHED • Mr. Riaz Mujtaba, Director Training, WASA Lahore (Secretary TAC) • Ms. Zaeema Amman, Deputy Director Training, WASA Lahore • Mr. Jawad Shahid, Vice Principal, E&M Specialist, Al-Jazari Academy • Ms. Rebia Suhail, Sr. Instructor, Al-Jazari Academy • Mr. Fahad, Instructor, Al-Jazari Academy • Mr. Muhammad Hafeez, JICA Coordinator • Mr. Ismaeel Azeem Khan, JICA Coordinator • Mr. Adnan Nisar Khan, Deputy Managing Director WASA Faisalabad (Online) • Mr. M. Nadeem, DD WASA Multan/ WASA Coordinator (Online) • Mr. Ali Hasnain, AD WASA Gujranwala (Online) • Mr. M. Haseeb, AD WASA Rawalpindi (Online) Japanese side • Dr. Nobuyuki Sato, Chief Advisor, JICA Experts Team • Mr. Tatsuo Tomidokoro, JICA Experts Team • Mr. Yusaku Numajiri, JICA Experts Team • Mr. Kazuhiro Kayanoma, JICA Experts Team (Online)	
Decisions	1. Technical Advisory Committee approved the proposed schedule and contents of professional training for "O&M of Mechanical and Electrical Equipment" from 26th to 28th of December, 2022. 2. Technical Advisory Committee approved the proposed schedule and contents with few changes of professional training for "Leakage Control, Plumbing and Pipe Replacement Plan" from 17th to 19th January, 2023. 3. Committee also endorsed the following:	

	i. Practical activity approach using applicable Softwares for "Professional Training" ii. Site visiting tour at WASA Faisalabad and other WASAs iii. The discussion for the improvement of professional and in-house trainings among HUD, WASAs and AJWA

DISCUSSION

The meeting started with opening remarks from the chair.

- The Chief Advisor, JICA Experts Team, explained the agenda and brief regarding following:
  1. Approval of professional training of "O&M on Mechanical and Electrical Equipment" from 26th to 28th December, 2022.
  2. Approval of professional training of "Leakage control, Plumbing and Pipe Replacement Plan" from 17th to 19th January, 2023
  3. Training program in Japan on May - June 2023.
  4. Progress of In-house training at each WASA.

  For the training at AJWA, Chief Advisor emphasized on an importance of constructive and interactive learning in the training. He explained the benefits of mWater application for database development.

Training course "O&M on Mechanical and Electrical Equipment":

Mr. Jawad explained the time schedule and activity-outcomes of the training course, "O&M of Mechanical and Electrical Equipment". He further explained i) the feedback of trainees in the course of "O&M on Sewerage and Drainage" conducted from 22nd to 24th of November, 2022, and ii) improvements in the upcoming cycle based on that feedback by the trainees form the previous training of "O&M of Mechanical and Electrical Equipment". He proposed the following improvements in the existing training contents:

i) use of mWater Application

ii) use of QGIS

iii) introduction, installation, and uses in the field

The proposal was approved by the committee.

Training course, "Leakage Control, Plumbing and Pipe Replacement Plan":

Ms. Rebia explained the time schedule, contents and activity-outcomes of the training course, "Leakage Control, Plumbing and Pipe Replacement Plan". She proposed following changes in the existing course:

i) Pipe network model to install OHR to compare the difference between gravity and pressurized flow

ii) How to use ultrasonic flow meter

iii) HDPE pipes butt fusion joint

iv) mWater and QGIS in the field

The committee approved with following changes in the proposed course:

Mr. Hisham recommended to exclude component of making connection with OHR during training session as it has no practical implication. Instead proposed to include Pros & cons of existing Supply methodologies in different WASAs with the use of examples such as direct supply or supply through OHR. Site visits of respective WASAs to witness the aforestated methodologies may also be included.

Mr. Adnan endorsed the proposal and recommended site visit to WASA Faisalabad for visit of water supply scheme where Water supply is being maintained through OHR.

General Recommendations by the Committee:

- Mr. Souman recommended that the faculty of AJWA and the master trainers of WASA Lahore should work together to prepare the course outline. The faculty of AJWA may participate the in-house trainings at all WASAs to enhance their learning. As a result, both sides can learn from each other to improve the quality of trainings. He also informed that the department received the request of procuring equipment for the professional and inhouse trainings from AJWA. He requested all WASAs to go through the list and review the need of equipment for the in-house trainings. He insisted WASA Lahore for participation in all AJWA Trainings irrespective of same course being conducted in-house. He also recommended to add training on water meter of all types being used in all WASAs
- Mr. Hisham proposed that in case AJWA Faculty has to participate in in-house trainings, they may send written request to respective WASA.

- Mr. Ali requested the training of mWater application for further extended contents. He explained the benefits of visiting sites of WASA Lahore during trainings, and requested to have trainings at the sites of other WASAs especially at WASA Faisalabad.
- Mr. Adnan concurred with the proposal to invite trainees & respective AJWA Faculty members.
- Ms. Zaeema explained the progress of the in-house trainings of WASA Lahore.
- Mr. Adnan explained the progress of the in-house trainings of WASA Faisalabad.
- Mr. Nadeem explained the progress of the in-house trainings of WASA Multan. He informed that WASA Multan has been using m-water application to record crown failure of sewer pipes. In addition, he requested to have the velocity meter once in a month for maintaining the flow rate data of Waste Water Treatment Plant.
- Mr. Ali explained the progress of the in-house trainings of WASA Gujranwala. He explained that the number of complaints by customers in sewerage sector have reduced as low as 70% by the application of preventive maintenance through in-house trainings.
- Mr. Haseeb explained the progress of the in-house training of WASA Rawalpindi.
- Mr. Jawad informed that AJWA staff accompanies JICA experts to WASAs for the development of in-house trainings. He agreed on the recommendation of AJWA's involvement for the in-house trainings. He furthers agreed with the idea of taking trainees to other WASA as well.
- Dr. Sato appreciated the open discussion by the forum to improve quality of professional and in-house trainings. He requested the continuation of similar discussions which are very important for the sustainability.
- Chair thanked JICA experts for their support, and approved both professional trainings. He also recommended further discussions on the other agenda items by Chief Advisor, AJWA and WASAs.

Annex 5.1.37 MM on 6th TAC held on 3rd March, 2023

MINUTES OF MEETING

6th Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"

Lahore, March 3rd, 2023.

Mr. Mian Muhammad Munir,
Deputy Managing Director (F, A&R),
WASA Lahore.

佐藤伸幸
Dr. Nobuyuki Sato,
Chief Technical Advisor,
JICA Expert Team.

MINUTES OF MEETING		
Subject:	6th Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"	
Date:	Friday, March 3, 2023	Time: 11:30 am
Venue:	Head office, WASA Lahore.	
Participants:	Pakistani side • Mian Muhammad Munir, Deputy Managing Director (F, A&R) (Chairperson) • Mr. Souman Khalid, Deputy Secretary, HUD&PHED • Mr. Hisham Pervaiz Vasser, Project Director Planning (LWWMP) / Focal Person (Foreign Trainings), WASA Lahore • Mr. Riaz Mujtaba, Director Training, WASA Lahore (Secretary TAC) • Mr. Saleem Ashraf, DMD WASA Rawalpindi (Online) • Mr. Roohan Javaid, Director WASA Faisalabad/ WASA Coordinator (Online) • Mr. M. Nadeem, DD WASA Multan/ WASA Coordinator (Online) • Mr. Ali Hasnain, AD WASA Gujranwala (Online) • Mr. Jawad Shahid, Vice Principal, E&M Specialist, Al-Jazari Academy • Mr. Salman Hashmi, Al-Jazari Academy • Mr. Mujtaba Bashir, Al-Jazari Academy • Mr. Muhammad Hafeez, JICA Coordinator Japanese side • Dr. Nobuyuki Sato, Chief Advisor, JICA Expert Team • Mr. Hiroyuki Tabusa, JICA Expert Team (Online) • Ms. Mikiko Azuma, JICA Expert Team (Online)	
Decisions	Technical Advisory Committee approved the proposed schedule and contents of professional training for "O&M of Mechanical and Electrical Equipment" from 7th to 9th March 2023.	
DISCUSSION		
The meeting started with opening remarks from the chair.		

- Dr. Sato informed the agenda of the meeting to discuss and approve the schedule and contents of professional training for "O&M of Mechanical and Electrical Equipment" from 7th to 9th March 2023.
- Mr. Jawad explained the schedule and contents for the training course. He further explained the learning outcomes of each component of the training.
- Mr. Hisham recommended that the solar energy section should include working out the requirements and maintenance of the system by the participants. He further recommended that a well developed scenario-wise action plan should be prepared by the trainers and presented in TAC meeting for approval on which the trainees could be trained to practice in field. He reminded that the training content must be the one which is duly approved by TAC. He further added that trainings should be related to daily on-job work by WASA. He recommended that the requests by other participants to include detailed design of components may be taken into consideration subject to need-based assessment in next phase (Phase 3) of the project.
- Mr. Roohan requested to include the content for detailed design sizing of the panel, cables and its components, updating drawings after completion of troubleshooting and also include trouble shooting at installations required on daily basis at field. He further told that there should be no lecture, only hands-on activities should be included.
- Mr. Souman added that a smart blend of both lectures and hands-on activity should be used but lectures should be for the introduction only. AJWA should develop custom build models related to scenario of each WASA to provide hands-on trainings to the trainers.
- Mr. Ali requested to add the detailed design courses in the civil, mechanical and electrical sections particularly related to disposal station.
- Dr. Sato explained that some components of design is included in the training individually. A complete design course will be too long and may not be feasible to cover in this project.
- Mr. Jawad agreed to the suggestion to add the customized action plan and sizing of control panel as discussed. Two activities are already added which include making of basic MCU circuit and plotting Q-H curve on miniature pumping station. More can be added on a later stage. He further informed to the forum that as per mandate of TAC mentioned in the record of discussion, curriculum of three courses under supported by JICA experts is discussed and approved in this forum whereas Al-Jazari Academy is conducting a total number of 21 courses yearly. In addition, he requested WASAs to send the nominations for the approved training. He apprised the forum that custom made models have been developed by the academy.

- Chair thanked JICA experts for their support, and approved the professional training for "O&M of Mechanical and Electrical Equipment" from 7th to 9th March 2023.

Annex 5.1.38 MM on 7th TAC held on 5th April, 2023

MINUTES OF MEETING

7th Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"

Lahore, April 5th, 2023.

佐藤伸幸

Mr. Mian Muhammad Munir,
Deputy Managing Director (F, A&R),
WASA Lahore

Dr. Nobuyuki Sato,
Chief Technical Advisor,
JICA Expert Team,

<table>
<tr><th colspan="3">MINUTES OF MEETING</th></tr>
<tr><td>Subject:</td><td colspan="2">7th Technical Advisory Committee Meeting for the Project Titled “The Project for Improving the Capacity of WASAs in Punjab Province Phase 2”</td></tr>
<tr><td>Date:</td><td>Wednesday, 5 April, 2023</td><td>Time: 11:30 AM</td></tr>
<tr><td>Venue:</td><td colspan="2">Head office, WASA Lahore.</td></tr>
<tr><td>Participants:</td><td colspan="2">Pakistani side
• Mr. Souman Khalid, Deputy Secretary, HUD&PHED
• Mr. Riaz Mujtaba, Director Training, WASA Lahore (Secretary TAC)
• Mr. Hisham Pervaiz Vasser, Project Director Planning (LWWMP) / Focal Person (Foreign Trainings), WASA Lahore
• Ms. Zaeema Aman, Deputy Director, Training Center
• Mr. Roohan Javed, Director Works/WASA Coordinator, WASA Faisalabad
• Mr. Saleem Ashraf, DMD, WASA Rawalpindi (Online)
• Mr. M. Nadeem, Deputy Director, WASA Multan/ WASA Coordinator (Online)
• Ms. Rebia Suhail, Sr. Instructor, Al-Jazari Academy
• Mr. Salman Hashimi, Instructor, Al-Jazari Academy
• Mr. Muhammad Hafeez, JICA Coordinator
Japanese side
• Dr. Nobuyuki Sato, Chief Advisor, JICA Experts Team
• Mr. Tatsuo Tomidokoro, JICA Experts Team</td></tr>
<tr><td>Decisions</td><td colspan="2">1. Technical Advisory Committee approved the proposed changes in schedule and contents of professional training for "O&M of Mechanical and Electrical Equipment" from 2nd to 4th of May, 2023.
2. Technical Advisory Committee approved the proposed changes in schedule and contents of professional training for "Leakage Control, Plumbing and Pipe Replacement Plan" from 29th to 31st May, 2023.</td></tr>
<tr><th colspan="3">DISCUSSION</th></tr>
<tr><td colspan="3">The Meeting started with opening remarks from the chair.
• Ms. Rebia Suhail, Sr Instructor Al-Jazari Academy, explained the agenda. The main items presented by her included:</td></tr>
</table>

1. Approval of professional training of "O&M on Mechanical and Electrical Equipment" from 2nd to 4th May, 2023.
2. Approval of professional training of "Leakage control, Plumbing and Pipe Replacement Plan" from 29th to 31st May, 2023.

For the training in AJWA, Ms. Rebia Suhail and Mr. Salman explained the previous trainings and newly added activities.

- Mr. Salman explained the schedule and activity-outcomes of the training course, "O&M of Mechanical and Electrical Equipment", and Ms. Rebia explained "Leakage Control, Plumbing and Pipe Replacement" She further explained the feedback of trainees and improvements in the upcoming training based on that feedback by the trainees from the previous trainings. It is also informed that its dashboard creation and analysis of the data by "mWater" application will be used in the training. And as new addition, design software "EPANET" will be introduced and used in the training on how to develop pipe network with necessary parameters. For mechanical component, "mWATER" application will be used on site for analyzing hydraulic parameters for energy audit. In this time, visiting lecturer from WASA Lahore will be invited for the more exposure and interaction of knowledge sharing between WASAs.
- Mr. Salman Hashmi explained that asset risk management, mWATER and hydraulic parameters are newly added in the training "Operation and maintenance of mechanical and electrical equipment".
- Mr. Hisham asked about the responsible person from AJWA for energy audit, and a visiting lecturer from WASA Lahore.
- Ms. Rebia answered that it will be coordinated with Mr. Waqas Liaqat. He can give some briefing on operation and maintenance. Mr. Salman told that he is the trainer for energy audit. Then for site activity of energy audit, it could be jointly carried out.
- Mr. Hisham told that mWATER and QGIS analysis need more data from multiple sites. In addition, the time allocation should be 1 day for mWATER and QGIS, and 2 days for design software "EPANET".
- Mr. Souman Khalid asked i) difference between previous and in this content for leakage control, plumbing and pipe replacement course, and ii) any possibility to conduct training for 4 days as participants can learn more about design software.
- Ms. Rebia answered that i) mWATER dashboard creation for leakage repair site and analysis is newly added, and ii) EPANET for designing water supply system is newly added. For leakage

repair site, we will coordinate with WASA Lahore.

- Dr Sato told that Mr Kinno will attend the training. His assignment is very limited. Therefore, "Leakage control, Plumbing and Pipe Replacement Plan" in this time is focused on more to software. The training could be done for 4 days. However, it might be difficult for WASA staff to attend due to the daily work.
- Mr. Roohan asked how to analyze the data. The water supply network is different in Lahore and Faisalabad. Water source in Lahore is ground water. On the other hand, surface water but from very far canal is used in Faisalabad.
- Mr. Salman Hashmi answered the activity of form creation on mWATER as per WASA's needs.
- Ms. Rebia told that mWATER portal (in-built features) will be prepared based on WASA's needs.
- Ms. Zaeema asked the trainer for the training of EPANET. If the participants do not have the background, it may be difficult to learn.
- Mr. Hafeez told that WASA Lahore is interested in design software. If the training on EPANET design software includes from basics, it is easier for the participants to understand.
- Ms. Rebia explained that the training on EPANET software includes basic features, creation of a pipe network model, and designing of water supply system.
- Mr. Hisham suggested the submission of formal request to MD WASA Lahore for the visiting lecturer from WASA Lahore, which was endorsed by the rest of the participants.
- Mr. Nadeem told the course content is fine. The activity and design-based software will be helpful. In addition, visiting lecturer from WASA Lahore will be valuable because WASA Lahore has multiple type of data on GIS and hands on experience of field.
- Closing remarks: Both course contents and activities were approved.

Annex 5.1.39 MM on 8th TAC held on 5th October, 2023

MINUTES OF MEETING

8th Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"

Lahore, October 5th, 2023.

Mr. Mian Munir
Deputy Managing Director(F,A&R)
WASA Lahore

佐藤伸幸

Dr. Nobuyuki Sato,
Chief Technical Advisor,
JICA Expert Team,

MINUTES OF MEETING		
Subject:	8th Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"	
Date:	Thursday, October 5th, 2023	Time: 11:00 am
Venue:	Head Office, WASA Lahore.	
Participants:	Pakistani side: • Mr. Mian Muhammad Munir DMD (FA&R), WASA Lahore (Chairperson) • Mr. Riaz Mujtaba, Director Training, WASA Lahore (Secretary TAC) • Mr. Abid Hussainy, Principal Al-Jazari Academy, The Urban Unit (Online) • Mr. Hisham Pervaiz Vasser, Project Director Planning (LWWMP) / Focal Person (Foreign Trainings), WASA Lahore • Mr. Roohan Javaid, Director Sewerage, WASA Faisalabad • Mr. Jawad Shahid, Vice Principal, E&M Specialist, Al-Jazari Academy • Mr. Hassaan Ullah Khan, Section Officer (Tech), HUD & PHED (Online) • Ms. Zaeema Aman, Deputy Director Training, WASA Lahore • Mr. M. Nadeem, Deputy Director WASA Multan (Online) • Mr. Ali Husnain, Deputy Director WASA Gujranwala (Online) • Mr. Muhammad Haseeb, Assistant Director WASA Rawalpindi (Online) • Mr. Salman Hashmi, Sr. Instructor, Al-Jazari Academy • Ms. Rebia Suhail, Sr. Instructor, Al-Jazari Academy • Mr. Fahad Hussain, Instructor, Al-Jazari Academy • Mr. Farhan, Instructor, Al-Jazari Academy • Mr. Uzair, Instructor, Al-Jazari Academy Japanese side • Dr. Nobuyuki Sato, Chief Advisor, JICA Experts Team • Mr. Kazuhiro Kayanoma, JICA Experts Team • Mr. Muhammad Hafeez, JICA Coordinator • Mr. Wajih-Ud-Din, JICA Coordinator	

Decisions	1. Technical Advisory Committee approved the proposed schedule and content of professional training for "Leakage Control, Plumbing and Pipe Replacement Plan" from 18th to 20th October, 2023. (attached as Annex-A)) 2. Technical Advisory Committee approved the proposed schedule and content of professional training for " O&M of Electrical and Mechanical course" from 21st November to 23rd November, 2023. (attached as Annex-B)

DISCUSSIONS

The Meeting started with opening remarks and welcome from the Chairperson.

- Engr. Rebia Suhail explained the plan of professional training "Leakage Control, Plumbing and Pipe Replacement Plan", which includes new topics of training regarding reduction of physical losses.
- Mr. Hisham highlighted that practical activity on 3rd day for leakage detection complements the overall purpose of instant training. However, the use of leak detection equipment is not feasible in water supply system of WASA Lahore owing to limited access & insufficient number of known valves locations, and low pressure in distribution lines due to intermittent water supply. However, he explained that it might be feasible to use equipment in Johar Town Pilot area/training center Gulshan-e-Ravi. He further apprised that WASA Lahore is developing Pilot DMAs where leakage detection activity can be carried out on routine basis.
- Mr. Jawad Shahid shared his experience in Phase 1 on the difficulty of identifying leakage from water pipe deeply installed from the surface of ground even through use of equipment.
- Engr. Rebia Suhail said if site was not arranged then leakage detection yard may be used for practical activity, which was established in Phase-1 at AJWA.
- Mr. Hafeez explained that the training would be for beginners' level and related to patrol along pipelines. The activity regarding leakage training was proposed at a site near the academy.
- Mr. Rohan explained that WASA Faisalabad has only 3 isolated areas with sufficient pressure for leak detection activity. Sometimes acoustic leak detector & helium method is not suitable under service condition of WASA Faisalabad. We should obtain knowledge and skills on some other ways and easier methods to identify leakages.
- Mr. Hisham explained that leakage detection in water supply lines is carried out mostly for resolving complaints of water shortage, low pressure or contaminated water without use of equipment. However, focus should also be diverted towards using leakage detection equipment for water conservation.

- Ms. Zaeema asked whether the nomination for the training topic on EPAnet software is separately selected or not.
- Engr. Rebia Suhail explained that the same or new trainees may participate in the course of "Leakage Control, Plumbing and Pipe Replacement Plan". However, WASA can decide who to nominate either the same as before or new. The training will include i) an inspection of theoretical data by EPAnet and actual values from water distribution model, and ii) analysis by comparison of both data.
- Mr. Salman Hashmi explained the plan of professional training "O&M of Electrical and Mechanical course".
- Mr. Hisham highlighted the comparison of feedback options in "Leakage Control, Plumbing and Pipe Replacement Plan" and "O&M of Electrical and Mechanical course". He suggested to use indicator of "not satisfactory" etc. in place of "Satisfactory" or "Good" as minimum level of grading.
- Engr. Rebia Suhail explained that we attended the international training, which recommended not to use such words due to discouragement of the trainer.
- Mr. Salman Hashmi informed that the feedback is now being used as shown in his course.
- Mr. Hafeez appreciated the Energy Audit activity, however he expressed that importance shall be given for recommendation of remedy (e.g.to use bigger impeller instead of replacing new pump and motor to improve discharge)
- Mr. Roohan suggested to include training on setting of critical temperature of motor thermistors, relays, their configurations, and pump sizing.
- Mr. Salman Hashmi explained that these are considered as "design component", which are not required to be added in this time.
- Mr. Hisham elaborated that recommended setting of breakers for motor protection or preventive action in case of some emergency situations/ trouble shooting may be added. He further recommended that input of KSB/Progressive may be sought on the remedies in practice during day-to-day trouble shooting activities as they are involved as outsourced-contractor for O&M of Tubewells of WASA Lahore.
- Mr. Abid Hussainy raised that due to Audio issue at last session of meeting, the committee could not get comments or reviews of WASA Gujranwala, Faisalabad and Multan on professional training. It was proposed to share the PPTs with WASA's comments and suggestion to be incorporated as appropriated for the upcoming training.

Annex 5.1.40 MM on 9th TAC held on 1st December, 2023

MINUTES OF MEETING

9TH TECHNICAL ADVISORY COMMITTEE MEETING FOR THE PROJECT TITLED "THE PROJECT FOR IMPROVING THE CAPACITY OF WASAs IN PUNJAB PROVINCE PHASE 2"

Lahore, December 1st, 2023.

Mr. Mian Munir
Deputy Managing Director(F,A&R)
WASA Lahore

佐藤伸幸

Dr. Nobuyuki Sato,
Chief Technical Advisor,
JICA Expert Team

MINUTES OF MEETING		
Subject:	9th Technical Advisory Committee Meeting for the Project Titled "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2"	
Date:	Friday, December 1st, 2023	Time: 11:00 am
Venue:	Head Office, WASA Lahore.	
Participants:	Pakistani side: • Mr. Mian Munir, Deputy Managing Director (F,A&R), WASA Lahore (Chairperson) • Mr. Hisham Pervaiz Vasser, Project Director Planning (LWWMP) / Focal Person (Foreign Trainings), WASA Lahore • Mr. Riaz Mujtaba, Director Training, WASA Lahore (Secretary TAC) • Mr. Abdul Latif, Director Planning and Evaluation, WASA Lahore • Ms. Zaeema Aman, Deputy Director Training, WASA Lahore • Mr. Asad Ali, Deputy Director Design, WASA Faisalabad • Mr. Hassaan Ullah Khan, Section Officer (Technical), HUD & PHED (Online) • Mr. M. Nadeem, Deputy Director, WASA Multan (Online) • Mr. Abdul Wahab, Deputy Director Operation and Maintenance. WASA Gujranwala (Online) • Mr. Muhammad Haseeb, AD M&E, WASA Rawalpindi (Online) • Mr. Muhammad Irfan, Water & Sewerage Specialist (AJWA) • Mr. Syed Fahad Hussain, Instructor Sewerage (AJWA) • Mr. Muhammad Uzair Safdar, Instructor Water Quality (AJWA) Japanese side • Dr. Nobuyuki Sato, Chief Advisor, JICA Experts Team • Mr. Tatsuo Tomidokoro, JICA Experts Team (Online) • Mr. Yusaku Numajiri, JICA Experts Team (Online) • Mr. Muhammad Hafeez, JICA Coordinator	
Decisions	1. Technical Advisory Committee approved the proposed schedule and content of professional training for "O&M on Sewerage and Drainage" from 12th to 14th December, 2023.	

DISCUSSIONS

The Meeting started with opening remarks and welcome from the Chairperson.

- Syed Fahad Hussain explained the agenda of the meeting and started his presentation on Professional Training of "O&M of Sewerage & Drainage" from 12th to 14th December 2023.
- His explanation included the revised contents, which are i) Analysis of Crown Failure Data on mWater Portal, ii) Visiting Faculty from WASA Multan to share their knowledge regarding crown failures, iii) Use of Metal Locator to find out the lost / buried manholes (previous training feedback), iv) Estimation of drain sludge volume using mWater (previous training feedback).
- Mr. Hassaan commented that foreign countries having same issues such as crown failure etc. should also be included in the training.
- Mr. Irfan explained that example of WASA Multan is included in the training. The international examples will also be considered for future trainings.
- Mr. Hisham said that WASA Lahore also faces crown failure issues and have more experienced officers regarding the issue on crown failure. The experience on WASA Lahore could also be added into the trainings.
- Mr. Irfan acknowledged it.
- Mr. Irfan explained real time calculation of sludge which includes i) sludge measuring rod, ii) cross section, iii) length of the drain etc.
- Mr. Hisham mentioned that sections of drains are not uniform and varies width and depth at place to place. In case of the calculation by WASA, bucket size, excavator type, capacity of dump truck, number of buckets are used. Therefore, this method shall be more useful and included in the training.
- Mr. Irfan acknowledged to add WASA's calculation methodology.
- Dr. Sato emphasized that the coordination between WASA expert and academy shall be made before training.
- Mr. Hafeez emphasized that calculation should be made on intermediate / secondary drain around 20 feet wide instead of a small width drain at Moulana Shoukat Ali Road, which is usually chosen by the AJWA for this purpose.
- Mr. Hisham mentioned that crown failure are few in a year. Therefore, the data registration on mWater would not be so beneficial. On the other hand, the leakage issue occurs daily basis repaired by the lower staff. These are not much known to the management. Therefore, the leakage data may be beneficial to be saved on mWater for the information to the management.

- Mr. Nadeem highlighted that the issue of crown failure is very critical as they have been facing multiple crown failure complaints all around Multan. A map showing the location of crown failure in Multan was also shown in the meeting and emphasized the importance of analysis.
- Ms. Zaeema mentioned regarding a proposal of Mr. Tomidokoro that the field staff shall be included for the training since the staff have less theoretical knowledge of crown failure.
- Mr. Hafeez mentioned that material of manhole cover has been shifted from metallic to non-metallic. Therefore, metal locators will not be used for finding manhole covers.
- Mr. Hisham mentioned that WASA should be careful and more vigilant when there is road construction work because it is very difficult to find non-metallic manhole covers once covered by under asphalt. Therefore staff need to mark manholes on m-water or GIS.
- Mr. Hassaan mentioned according to his experience in attending the training that in many cases, guest speakers explained more to field work with a wide variety of experiences but less academic concept and less skill as lecturers. AJWA and WASA Training Center need to be considered.
- Mr. Irfan acknowledged it.
- Ms. Zaima suggested a meeting with the guest speaker before the training.
- Mr. Irfan thanked JICA and Japanese experts. He mentioned that he learned a lot from JICA projects since 2016.
- Mr. Hisham thanked everyone and closed the meeting.

Annex 5.1.41 Time Schedule for Training in Summer 2022

Operation & Maintenance of Sewerage and Drainage System
Training Schedule (JICA Phase-II) 2022

Sr. No.	Day and Date	Module Name	Session-1			Tea 10:45 am-11:00 am	Session-2			Lunch 1:15 pm-2:00 pm	Session-3	
			1st Lecture		2nd Lecture		3rd Lecture		4th Lecture		5th Lecture	6th Lecture
			09:00 am-9:15 am	9:15 am-10:00 am	10:00 am-10:45 am		11:00 am-11:45 am	11:45 am-12:15 pm	12:15 am-1:15 pm		2:00 pm-3:30 pm	3:30 pm-4:00 pm
1	Monday June 13, 2022	**Module 01** **Cleaning of Sewerage & Drainage Pipelines**	• Welcoming Remarks • Participant Introduction • Course Overview • Training Expectations	• Removal of Blockages in Sewer Lines • Latest Cleaning Techniques of Sewerage & Drainage System	• Introduction to Sewer Camera (Parts + Working) **(Demonstration)** • Repair & Maintenance of Sewerage & Drainage Pipelines		**FIELD WORK** **(Unpack-Assemble-Install-Use-Packing)** • Manhole & Sewer & Inspection with Camera				**FIELD WORK** • Manhole & Sewer & Inspection with Camera (Evalution of Manhole & Sewer)	• Quick Win Measures (QWMs) • Conclusion on Day's Activities
2	Tuesday Jun 14, 2022	**Module 02** **Flow Measurement of Open Channels**	• Recap of Previous Day Activities	• Objectives • Types of Drains • Methods & Formulae	**FIELD WORK** **(Unpack-Assemble-Install-Use-Packing)** • Velocity Meter	**Tea Break (As per Site Visit Situation)**	**FIELD WORK** **(Unpack-Assemble-Install-Use-Packing)** • Velocity Meter			**Lunch & Prayer Break (As per Site Visit Situation)**	**FIELD WORK** • Measuring Flow Velocity in Open Chanel • Calculation of Flow Rate	• Quick Win Measures (QWMs) • Conclusion on Day's Activities
3	Wednesday Jun 15, 2022	**Module 3 & 4** **Wastewater Treatment (WWT)**	• Basics of WWT • WWT Technologies	• Rapid Testing of Wastewater Samples with Kits (BOD, pH, DO)	• How to Clean & Maintain Ponds of WWTP		• Fianacial Comparison of Various Technology w.r.t. CAPEX & OPEX				• Most Suitable Technology	• Reflections • Group Picture • Certificates

Academy Team: Engr. Muhammad Irfan, Engr. Syed Fahad Hussain, Engr. Haris Bin Khawar

Time Schedule of O&M of Mechanical Equipment Training (Draft)

1st Day: 16th June (Thu)		
Time	**Activity**	**Notes**
9:30 to 9:45	Introduction Orientation	
9:45 to 11:00	Basics of Pump ・Typical components of pump facility. ・Hydraulic parameters (Flow Rate, Discharge Pressure, Total Head) ・Electrical parameters (Voltage, Ampere) ・Parallel & series pump operation ・Pump performance curve (Relationship between flow and discharge pressure) ・Relationship between flow and current	Exercise by using the pump model Trainees will check/measure each parameter by themselves. Trainees will demonstrate each iems by using the pump model.
11:00 to 12:00	Understanding of Ultrasonic Flow Meter ・What will happen if we don’t follow 10d recommendatio ・What will happen if the setting value of pipe thickness is wrong ? ・What will happen if the setting value of pipe diameter is wrong ? ・What will happen if the setting of pipe material is wrong ・What will happen if the installation distance of sensor is not proper ?	Exercise by using the pump model Trainees will demonstrate each iems by using a ultrasonic flow meter on the pump model.
12:00 -13:00	Basics of Asset lifecycle analysis with examples.	Concept of Asset Life cycle analysis
13:00 to 14:00	*Lunch & Prayer Break*	
14:00 to 15:00	Data Analysis ・Making a pump performance curve by Excel.	Exercise by using Excel. (PCs shall be prepared.)

2nd Day: 17th June (Fri)		
Time	**Activity**	**Notes**
9:30 to 10:30	Vibration Analysis and its importance Understanding of Vibration Meter ・Use of Vibration Meter ・ Installation of Vibration Meters on Machinery	
10:30 to 11:00	*Move to the Site*	
11:00 to 13:00	Site Visit to WASA Disposal Station Prepration of Mainteniance Plan for Facility	Practical Training at the site
	Vibration Measurement	
13:00 to 14:00	・Vibration measurement	
14:00 to 14:45	・Filling the record sheet	
14:45 to 15:00	*Lunch & Prayer Break*	
	Preparation of Report, Q&A	
	Closing	

Annex 5.1.42 Time Schedule for Training in Fall 2022

PROGRAM AGENDA

3-Days Training on "Leakage Control, Plumbing and Pipe Replacement Plan"

1st Day 25 Tuesday October,2022

Time	Topics/Description	Resource Person
08:30 am - 09:00 am	Attendance and Seating	Muhammad Mujahid
09:00 am - 09:10 am	Recitation of Holy Quran	
Opening Session		
09:10 am - 9:20 am	Opening and Welcome Remarks	Principal AJWA
09:20 am - 09:30 am	Introduction – Participants and Trainers Expectations from the Training	All
09:30 am – 09:40 am	Contents and Objectives of the Course	Engr. Rebia Suhail
Ice-Breaking Session		
09:40 am – 10:00 am	Ice-Breaking:	Ms. Najam-ul-Sahar
10:00 am – 10: 15 am	Program Agenda of Training	Engr. Rebia Suhail
Introductory Sessions		
10:15 am – 10:30 am	Introduction to m-Water App	Engr. Rebia Suhail
10:30 am – 11:00 am	Downloading and Installation of M-Water App/Portal	Engr. Haris-Bin-Khawar
11:00 am – 11:15	Tea Break	
11:15 am – 11:30 am	Activity Form (Form Filling)	Engr. Haris-Bin-Khawar
11:30 am – 12:30 pm	Form Creation Activity	All
12:30 am – 01:00 pm	Worksheet (Assignment)	All
01:00 pm – 02:00 pm	Lunch and Prayer Break	
02:00 pm – 02: 30 pm	Introduction to Q-GIS	Engr. Uzair Safdar and Muhammad Mujahid
02:30 pm – 03: 00 pm	M-Water Data Input in Q-GIS	All
03:00 pm – 03:30 pm	Visualization and Presentation of Leakage Repair Data in Q-GIS	All
03:30 pm – 03:45 pm	Presentation of Activity	Participants
03:45 pm – 04:00 pm	Implementation Plan in all WASAs/Departments	Participants

PROGRAM AGENDA

3-Days Training on "Leakage Control, Plumbing and Pipe Replacement Plan"

2nd Day 26 Wednesday October,2022

Time	Topics/Description	Resource Person
09:00 am - 09:15 am	Attendance and Seating	Course Team
09:15 am - 09:30 am	Pre-Evaluation Form	Rabbia Naimat
Opening Session		
09:30 am - 9:40 am	Module Overview	Mr. Kayanoma
09:40 am - 09:50 am	Course Objectives	Engr. Fahad Hussain
09:50 am – 10:00 am	Program Agenda & Learning Outcomes	Engr. Rebia Suhail
Interactive Sessions		
10:00 am – 10:30 am	Demonstration of Water Pipe Network Model	Engr. Fahad Hussain
10:30 am – 11:00 am	Identification of components (Activity)	Engr. Rebia Suhail
11:00 am – 11:15	Tea Break	
11:15 am –11:45 am	Assembling and Dissembling of Different Type of Meters	Engr Fahad Hussain and Mr. Kayanoma
11:45 am – 12:15 pm	How to Read the water meters (Activity)	Course Team and Participants
12:15pm – 12:45 pm	Comparison of Bulk Meter with Consumer Meters (Activity)	Course Team and Participants
12:45 am – 01:15 pm	Measure NRW by Creating Leakage	Engr Fahad Hussain
01:15 pm – 02:00 pm	Lunch and Prayer Break	
02:00 pm – 02:30 pm	Water Meter Accuracy by using Bucket of 5 Liter (Activity)	Course Team and Participants
02:30 pm – 03:00 pm	Pressure and Flow Measurements by using Gate Valve	Mr. Wajih (JICA Team)
03:00 pm – 03:40 pm	Cutting and Jointing of PPRC Pipe (Activity and Competition)	Participants & Course Team
03:40 pm – 03:50 pm	Post Evaluation Forms	Najam-ul-Saher
03:50 pm – 04:00 pm	Conclusion on day's Activities	Engr. Rebia Suhail

PROGRAM AGENDA

3-Days Training on "Leakage Control, Plumbing and Pipe Replacement Plan"

3rd Day **27** Thursday
October,2022

Time	Topics/Description	Resource Person
09:00 am - 09:30 am	Attendance and Seating	Muhammad Mujahid
09:30 am - 09:40 am	Pre-Evaluation Form	Rabbia Naimat
Opening Session		
09:40 am - 09:50 am	Module Overview	Dr. Satu
09:50 am - 10:00 am	Program Agenda and Learning Outcomes	Engr. Rebia Suhail
10:00 am – 10:05 am	Course Objectives	Engr. Farhan Riaz
Interactive Sessions		
10:15 am – 10:30 am	Parameters of HDPE Pipes	Engr. Farhan Riaz
10:30 am – 11:00 am	Exercise on Calculation of SDR & MOP	All Participants
11:00 am – 11:15	Tea Break	
11:15 am – 11:30 am	Assembling and Dissembling of Valves	Engr. Farhan Riaz
11:30 am – 12:00 pm	Components of Valves (Activity)	All Participants
12:00 pm – 12:15 pm	Demonstration of Pressure Test Activity	Engr. Farhan Riaz
12:15 pm – 01:15 pm	Activity on Pressure Testing Model	All Participants
01:15 pm – 02:00 pm	Lunch and Prayer Break	
02:00 pm – 02: 15 pm	Post Evaluation Form	Najm-ul-Saher
02:15 pm – 02: 30 pm	Reflections and Submission	All Paricipants
02:30 pm – 02:45 pm	Closing Remarks	Principal/VP
02:45 pm – 03:00 pm	Certificate Distribution and Group Photo	

O&M of Electrical and Mechanical Equipment

8th to 10th November 2022

Training Schedule

Sr. No.	Day & Date	Session I 09:00 AM - 10:00 AM	Session II 10:00 AM - 11:00 PM	Tea Break	Session III 11:15 AM - 12:00 PM	Session IV 12:00 PM - 01:00 PM	Lunch and Prayer Break	Session V 02:00 PM - 03:00 PM
1	**Tuseday** **8th Nov 2022**	- Introduction and Icebreaking - Expectations from Training -Introduction to Motor Control Unit -Operation of each component of MCU	**Commisioning of Motor Control Unit** Hands on Testing of Different components of MCU Connection and use of following items in MCU Switch ON / OFF MCCB / MCB Magnetic Contactor Electronic OV / UV Relay		**Commisioning of Motor Control Unit** Use of following items in circuit -Timer Relay -Voltmeter and ammeter -Water level switch for submersible pumps	**Commisioning of Motor Control Unit** Making of Motor Starters for MCU 1. DOL (Direct Online Circuit) 2. Star Delta Circuit		**Sizing of electrical Circuits** Cable Sizing MCCB Magnetic Contactor
2	**Wednesday** **9th Nov 2022**	**Previous Day's Wrap-up** -Insulation testing of Control Panel -Earth resistance Testing -Power Factor improvement	**Pratical Acticity on Energy Audit using miniature pumping station** -Electrical Parameters of Energy Audit - Mechanical Parameters of Energy Audit - Pump Performance Curve - Specific Energy		**Hands on Activity on Miniature Pumping Station** Typical components of pump facility. Hydraulic parameters (Flow Rate, Discharge Pressure, Total Head) Parallel & series pump operation QH Curve- Flow and Current Correlation Pump performance curve(Relationship between flow and discharge pressure) Comparison of Ultrasonic Flow meter with Velocity type Water meter	**Facility Failure analysis** -Pump Failure -Motor Failure -Control Panel Failure		**Causes of Failure for** -Vertical turbine Pump -Submersible Pump
3	**Thursday** **10th Nov 2022**	**Previous Day's Wrap-up** -How to Prepare Energy Audit Report -Energy Assesment Tool -Data Collection and Analysis using Excel -Energy benchmarking	Actual Issues faced during Energy Audit by WASAs -How to Prepare Energy Development Plan		**Industrial Visit to Control Panel Manufacturer** **or** **Field Visit to WASA Tubewell, Disposal Station** **Prepration and implementation of Mainteniance plan for Facility** - Energy Audit at WASA Tubewell -Hands on Use of Power Analyzer, Ultrasonic flow meter, power meter, Water Level Detector, Vibration Meter, Earth Resistance Tester. etc			**Prepration of Mainteniance Schedule by Participants** Process Improvement Operations Optimization Efficiency Planning Feedback on topics for upcoming training Evaluation of training Closing ceremony

Course Lead:	Mr. Jawad Shahid, Mr. Tabusa
Course Team	Mr. Farhan Riaz, Mr. Mujtaba Bashir, Mr. Talha Rashid

Operation & Maintenance of Sewerage and Drainage System
Training Schedule (JICA Phase-II) 2022

Sr. No.	Day and Date	Module Name	Session-1			Tea	Session-2	Lunch	Session-3	
			1st Lecture		2nd Lecture	Tea 11:00 am-11:20 am	3rd Lecture	Lunch 1:15 pm-2:15 pm	4th Lecture	6th Lecture
			09:00 am-9:15 am	9:15 am-10:00 am	10:00 am-11:00 am		11:20 am-01:15 pm		2:15 pm-3:15 pm	3:15 pm-3:30 pm
1	Tuesday 22 November 2022	**Module 01** **Cleaning of Sewerage & Drainage Pipelines**	• Welcoming Remarks • Recitation of Holy Quran & National Anthem • Participant Introduction • Course Overview	**Activity** • Sewer / Manhole Inspection with Camera (Public Awareness to Children Regarding Overflow from Sewer)		**Tea Break** **(As per Site Visit Situation)**	**FIELD WORK** **Demonstration** • Introduction to Sewer Camera (Parts + Working) **(Unpack-Assemble-Install-Use-Packing)** • Manhole & Sewer Inspection with Camera	**Lunch & Prayer Break** **(As per Site Visit Situation)**	**FIELD WORK** • Manhole & Sewer Inspection with Camera	• Quick Win Measures (QWMs) • Conclusion on Day's Activities
2	Wednesday 23 November 2022	**Module 02** **Flow Measurement of Open Channels**	• Recap of Previous Day Activities	**Class Room Activity** **(Unpack - Assemble- Install - Use - Packing)** • Velocity Meter			**FIELD WORK** **(Unpack-Assemble-Install-Use-Packing)** • Velocity Meter • Measuring Flow Velocity in Open Chanel		**Class Room Excercise** • Calculation of Flow Rate	• Quick Win Measures (QWMs) • Conclusion on Day's Activities
3	Thursday 24 November 2022	**Module 03** **Wastewater Treatment (WWT)**	• Recap of Previous Day Activities	• Rapid Testing of Wastewater Samples with Kits (BOD, pH, DO)			• Basics of WWT • Procedure for Selecting Best Wastewater Treatment Technologies (Comparison of Process, Land Requirement, Required Effluent Quality, CAPEX&OPEX)		• Cost Estimation of Sludge Removal including Volume Calculation and Work Plan Methodology	• Reflections • Group Picture • Certificates

JICA Team: Mr. Tomidokoro, Engr. Wajih
Course Lead: Engr. Syed Fahad Hussain,
Course Team: Engr. Muhammad Irfan

O&M of Electrical and Mechanical Equipment
26th to 28th December 2022

Training Schedule

Sr. No.	Day & Date	09:00 AM - 10:00 AM	10:00 AM - 11:00 PM		11:15 AM - 12:00 PM	12:00 PM - 01:00 PM		02:00 PM - 03:00 PM
1	**Monday 26th December 2022**	**Orientation Session** - Introduction and Icebreaking - Expectations from Training - Introduction to Pumps Introduction to Motors	**Operation and Maintenance of Pump Operation Data Tube well and Disposal Station and link and for record keeping** **Use of mWater application** **Introduction, Installation and Uses in Field**	**Tea Break**	**Basic O&M of 3-Phase induction motor** **Reliability based preventative maintenance** **Record the data for maintenance of motors using m-water application** **Energy Audit Parameters link with M-water application** - How to create form on m-water application for operation and maintenance of electrical and mechanical components - How can use the data and link with QGIS		**Lunch Break**	**Operation and maintenance of valves on Tube well ,Disposal and on pipe netwrok and record its data on m-water Application**
2	**Tuesday 27th December 2022**	**Energy Audit Activity on miniature pumping station** - Electrical Parameters of Energy Audit - Mechanical Parameters of Energy Audit - Pump Performance Curve - Specific Energy			**Hands on Activity on miniature pumping station** - Typical components of pump facility - Hydraulic parameters (Flow Rate, Discharge Pressure, Total Head) - Parallel & series pump operation - Flow and Current Correlation - Pump performance curve (Relationship between flow and discharge pressure) - Comparison of Ultrasonic Flow Meter with Velocity type Water Meter - **mWater exercise**	**Exercise** - Making pump performance curves in case of single, parallel and series pump operation Data collection and Analysis using Microsoft Excel - **mWater exercise**		**Scnario Based Learing Activity** - Pump Failure - Motor Failure - Control Panel Failure **Causes of Failure for** - Vertical turbine Pump - Submersible Pump - Protection measures for Pumps
3	**Wednesday 28th December 2022**	**Last Day's Wrap-up** - How to prepare Energy Audit Report - Energy Assesment Tool - Data Collection and Analysis using Excel - Energy benchmarking	**<u>Field Visit to WASA Disposal Station</u>** - Understanding of actual O&M activities - Exercise of Vibration & Ultrasonic Flow Meter - Filling the daily and monthly inspection sheet - Measurement of Electrical Parameters - Measurement of Hydraulic Parameters - Energy Audit of Disposal Station - Flow measurement through different techniques - Hands on use of Power Analyzer, Ultrasonic Flow Meter, Water Level Detector, Vibration Meter, Earth Resistance Tester. etc - **mWater exercise**					**Prepration of Maintenance Plan for Facility** (Process Improvement, Operations Optimization, Efficiency Planning) **Feedback on topics for upcoming training & Closing Ceremony**

Annex 5.1.43 Time Schedule for Training in Spring 2023

PROGRAM AGENDA

3-Days Training on “Leakage Control, Plumbing and Pipe Replacement Plan”

1st Day **17** Tuesday

Januaru,2023

Time	Topics/Description	Resource Person
09:15 am - 09:30 am	Attendance and Seating	Muhammad Mujahid
09:30 am - 09:35 am	Recitation of Holy Quran	Muhammad Mujahid
09:35 am – 09:40 am	National Anthem	Waqas
Opening Session		
09:40 am - 9:45 am	Opening and Welcome Remarks	Principal/VPAJWA
09:45 am - 09:55 am	Introduction – Participants and Trainers Expectations from the Training	All
09:55 am - 10:05 am	Module Overview	Mr. Kayanoma
10:05 am – 10:15 am	Program Agenda & Learning Outcomes	Engr. Rebia Suhail
Interactive Sessions		
10:15 am – 10:40 am	Demonstration of Water Pipe Network Model	Engr. Fahad Hussain
10:40 am – 11:00 am	Identification of components (Activity)	All Participants
11:00 am – 11:15	Tea Break	
11:15 am –12:00 am	Hands on Activity on Model	Engr. Fahad Hussain
12:00 am – 12:45 pm	How to Read the water meters (Activity)	Engr. Fahad and Participants
12:45pm – 01:15 pm	Assembling and Dissembling of Different Type of Meters	Engr Fahad Hussain and Mr. Uzair
12:45 am – 01:15 pm	Ultra-Sonic Flow meter	Uzair and Mujtaba
01:15 pm – 02:00 pm	Lunch and Prayer Break	
02:00 pm – 02:30 pm	Introduction to EPA.NET	Engr. Uzair Safdar
02:30 pm – 03:300 pm	Hands on Activity on EPA.NET	Participants & Course Team
03:30 pm – 03:40 pm	Post Evaluation Forms	Pedagogy
03:40 pm – 03:50 pm	Conclusion on day’s Activities	Engr. Rebia Suhail

PROGRAM AGENDA

3-Days Training on "Leakage Control, Plumbing and Pipe Replacement Plan"

2nd Day **18** Wednesday January,2023

Time	Topics/Description	Resource Person
09:15 am - 09:30 am	Attendance and Seating	Muhammad Mujahid
09:30 am - 09:40 am	Pre-Evaluation Form	Rabbia Naimat
Opening Session		
09:40 am - 09:50 am	Program Agenda and Learning Outcomes	Engr. Rebia Suhail
09:50 am - 10:00 am	Course Contents and Objectives	Engr. Farhan Riaz
Interactive Sessions		
10:00 am – 10:30 am	Demonstration for Procedure of Butt Fusion Welding	Engr. Farhan Riaz
10:30 am – 11:00 am	HDPE Pipes Parameters	Engr. Farhan Riaz
11:00 am – 11:15	Tea Break	
11:15 am – 11:30 am	Exercise on Calculation of SDR & MOP	All Participants
11:30 am – 12:30 pm	Hands-On Activity on Butt Fusion	All Participants
12:30 pm – 01:15 pm	Assembling and Disassembling of Valves and Threads (Activity Group1 & Group 2)	Engr. Farhan Riaz & Engr. Uzair Safdar
01:15 pm – 02:15 pm	Lunch and Prayer Break	
02:15 pm – 02: 30 pm	Post Evaluation Form	Pedagogy Team
02:30 pm – 02: 45 pm	Downloading and Installation of M-Water App/Portal	Engr. Uzair & Muhammad Mujahid
02:45 pm – 03:00 pm	Conclusion on day's Activities	Engr. Rebia Suhail

PROGRAM AGENDA

3-Days Training on “Leakage Control, Plumbing and Pipe Replacement Plan”

3rd Day **19** Thursday January,2023

Time	Topics/Description	Resource Person
09:15 am - 09:30 am	Attendance and Seating	Muhammad Mujahid
09:30 am - 09:40 am	Pre-Evaluation Form	Ms. Rabbya Naimat
Opening Session		
09:40 am - 10:00 am	Program Agenda and Learning Outcomes	Engr. Rebia Suhail
10:00 am - 10:15 am	Course Contents and Objectives	Engr. Uzair Safdar
Interactive Sessions		
10:15 am – 11:15 am	Form Creation Activity	Engr. Uzair Safdar
11:00 am – 11:15	Tea Break	
11:15 am –12:30 pm	On Site Form Filling Activity	Participants & Course Team
12:30 pm – 01:15 pm	Introduction to Q-GIS	Engr. Uzair Safdar
01:15 pm – 02:15 pm	Lunch and Prayer Break	
02:15 pm – 02: 30 pm	M-Water Data Input in Q-GIS	Muhammad Mujahid
02:30 pm – 03: 00 pm	Visualization and Presentation of Leakage Repair Data in Q-GIS	Muhammad Uzair
03:00 pm – 03:15 pm	Presentation of Activity	All Participants
03:15 pm – 03:30 pm	Quiz	All Participants
03:30 pm – 03:40 pm	Post Evaluation Forms	Pedagogy
03:40 pm – 03:50 pm	Conclusion on day’s Activities and Reflections	Participants
03:50 pm – 04:00 pm	Certificate Distribution and Group Photo	All Participants

Operation & Maintenance of Sewerage and Drainage System
Training Schedule (JICA Phase-II) February 2023

Sr. No.	Day and Date	Module Name	Session-1			Tea 11:00 am-11:20 am	Session-2	Lunch 1:00 pm-2:00 pm	Session-3	
			1st Lecture		2nd Lecture		3rd Lecture		4th Lecture	6th Lecture
			09:00 am-9:15 am	9:30 am-10:00 am	10:00 am-11:00 am		11:20 am-01:00 pm		2:00 pm-3:15 pm	3:15 pm-3:30 pm
1	Tuesday 14 February 2023	**Module 01** **Cleaning of Sewerage & Drainage Pipelines**	• Welcoming Remarks • Recitation of Holy Quran • Participant Introduction • Course Overview **(JICA Expert)**	**Demonstration** • Introduction to Sewer Camera (Parts + Working) (Unpack-Assemble-Install-Use-Packing) **(Mr. Fahad)**		**Tea Break**	**ACTIVITY** • Sewer / Manhole Inspection with Camera (Public Awareness to Children Regarding Overflow from Sewer) **(Mr. Irfan & Mr. Fahad)**	**Lunch & Prayer Break**	**FIELD WORK** • Manhole & Sewer Inspection with Sewer Camera **(Mr. Fahad)**	• Quick Win Measures (QWMs) • Conclusion on Day's Activities
2	Wednesday 15 February 2023	**Module 02** **mWater**	• Recap of Previous Day Activities **(Mr. Fahad)**	• Introduction to mWater App • Downloading and Installation of mWater App/Portal **(Mr. Uzair)**			**Hands-On Exercise** • Creation and Customization of Data Collection Form in mWater Portal **(Mr. Uzair)**		• How to Visualize Overflow & Crown Failure Data in QGIS • Analysis of Data in QGIS **(Mr. Uzair)**	• Quick Win Measures (QWMs) • Conclusion on Day's Activities
3	Thursday 16 February 2023	**Module 03** **Flow Measurement & Wastewater Treatment**	• Recap of Previous Day Activities **(Mr. Fahad)**	• Flow Rate Calculation by Excel **(Mr. Irfan & Mr. Fahad)**			• Rapid Testing of Wastewater Samples with Kits (BOD, pH, DO) • Sludge Estimation of Drain (Add on Demand) **(Mr. Fahad)**		• Reflections • Group Picture • Certificates	

JICA Team: Mr. Tomidokoro
Course Lead: Engr. Syed Fahad Hussain
Course Team: Engr. Muhammad Irfan, Engr. Uzair Safdar

O&M of Electrical and Mechanical Equipment

7th to 9th March 2023

Training Schedule

Sr. No.	Day & Date	09:00 AM - 10:00 AM	10:00 AM - 11:00 PM		11:15 AM - 12:00 PM	12:00 PM - 01:00 PM		02:00 PM - 03:00 PM
1	**Tuesday 7th March 2023**	**Orientation Session** - Introduction and Icebreaking - Expectations from Training -Introduction to MCU -Types of Control Panels	**Introduction to Different components of** MCU -MCB, MCCB -Magnetic Contactors - Use of Protective relays -PFI Capacitors	**Tea Break**	**Basic O&M of 3-Phase induction motor** Identification and rectification of faults Working and configuration of each component of MCU **Introduction to Motor Starters** 1. DOL (Direct Online Circuit) 2. Star Delta Circuit Importance of Power Factor Improvement Panel Single Line Diagram for Electrical Circuits, Causes and Effects of low Power Factor **Reliability based preventative maintenance** **Cable sizing and equipment (MCCB, MCB, Contactors Sizing)**		**Lunch Break**	**Hands on Activity Commissioning of a basic MCU** Connection and use of following items in MCU Switch ON / OFF MCCB / MCB Magnetic Contactor
2	**Wednesday 8th March 2023**	**Last Day's Wrap-up** - Components of MCU -Types of Panels - Parameters of Pumps and Motors	**Energy Audit Activity on miniature pumping station** - Electrical Parameters of Energy Audit - Mechanical Parameters of Energy Audit - Pump Performance Curve **- Scenario Based Learing Activity** - Pump Failure - Motor Failure - Control Panel Failure **Causes of Failure for** - Vertical turbine Pump - Submersible Pump - Protection measures for Pumps		**Hands on Activity on miniature pumping station** - Typical components of pump facility - Hydraulic parameters (Flow Rate, Discharge Pressure, Total Head) - Parallel & series pump operation - Flow and Current Correlation - Pump performance curve (Relationship between flow and discharge pressure) - Comparison of Ultrasonic Flow Meter with Velocity type Water Meter **Exercise** - Making pump performance curves in case of single, parallel and series pump	**Use of mWater application** - Creation of forms using mWater Application - Data Analysis using mWater Data collection and Analysis using Microsoft Excel		**Use of mWater applicaton** - Data input and creation of forms Data collection and Analysis using Microsoft Excel
3	**Thursday 9th March 2023**	**Last Day's Wrap-up** - How to prepare Energy Audit Report - Energy Assessment Tool - Data Collection and Analysis using Excel - Energy benchmarking	**Case Study Solarization of Disposal Station 0.75 MW** **Field Visit to WASA Disposal Station** - Identification for capacity for generation of Solar Energy - Types of Panels and Inverters Installed - Use of Motor Starters - Substation for Net-Metering	**Industrial visit to Largest control panel manufacturer of Pakistan PEMPAK Industries** -Different techonologies on Control Panel Manufacturing -Variable Frequency Drive -Sync Panels -Multi-Feeder Panels -Preventative Maintenance Protocols - Preventative Maintenance Schedule				**Prepration of Maintenance Plan for Facility / Action Plan according to Each WASA** (Process Improvement, Operations Optimization, Efficiency Planning) **Feedback on topics for upcoming training & Closing Ceremony**

Annex 5.1.44 Time Schedule for Training in Summer 2023

O&M of Electrical and Mechanical Equipment

May-23

Training Schedule

Sr. No.	Day & Date	09:00 AM - 10:00 AM	10:00 AM - 11:00 PM		11:15 AM - 12:00 PM	12:00 PM - 01:00 PM		02:00 PM - 03:00 PM
1	First Day	**Orientation Session** - Introduction and Icebreaking - Expectations from Training - Pre Evaluation Forms	**Operation and Maintenance of Pump Operation Data Tube well and Disposal Station and link and for record keeping use of mWater application Introduction, Installation and Uses in Field**	Tea Break	**Asset Risk and Condition Assessment** - Predictive Maintenance Techniques - Asset Risk and Condition Assessment of electromechanical components	**mWater Application** - Introduction to mWater application - How to collect and record data - Deployment of data collection forms for miniature model for energy audit	Lunch Break	**Hands-on activity on assembly and disassembly of valves with basic operation and maintenance techniques**
2	Second Day	**Orientation Session** - Introduction to performance measuring tools (Flow meter, Vibrometer, etc) - Parameters of Hands-on Activity	**Hands-on Activity on Miniature Pumping Station** - Typical components of pump facility - Hydraulic parameters (Flow Rate, Discharge Pressure, Total Head) - Parallel & series pump operation - Flow and Current Correlation - Pump performance curve (Relationship between flow and discharge pressure) - Comparison of Ultrasonic Flow Meter with Velocity type Water Meter		**Energy Audit Activity on miniature pumping station** - Electrical Parameters of Energy Audit - Mechanical Parameters of Energy Audit - Exercise of Vibration & Ultrasonic Flow Meter - Pump Performance Curve **Hands on Activity on miniature pumping station and data recording using mWater application.**			**Exercise** **- Demostration of Data Visualisation on mWater Portal** **- Introduction of pump performance curves in case of single, parallel and series pump operation**
3	Third Day	**Last Day's Wrap-up** - How to prepare Energy Audit Report - Energy Assesment Tool - Data collection and Analysis using Excel - Energy benchmarking	**Field Visit to WASA Tube Well Station** - Understanding of actual O&M activities - Exercise of Vibration & Ultrasonic Flow Meter - Filling the daily and monthly inspection sheet - Measurement of Electrical Parameters - Measurement of Hydraulic Parameters - Energy Audit of Tube well pump Station - Flow measurement through different techniques - Hands on use of Power Analyzer, Ultrasonic Flow Meter, Water Level Detector, Vibration Meter, Earth Resistance Tester. etc - **mWater exercise**					**Prepration of Maintenience Plan for Facility** (Process Improvement, Operations Optimization, Efficiency Planning) **Feedback on topics for upcoming training & Closing Ceremony**

LEAKAGE CONTROL, PLUMBING & PIPE REPLACEMENT PLAN

Tentative Training Schedule (JICA Phase-II) 2023

Sr. No.	Day & Date	Module Name	Introductory Session 09:00 am-9:15 am	Session-1 9:15 am-11:00 am	Tea Break 11:00am-11:15 am	Session-2 11:15 am-1:15 pm	Lunch & Prayer Break 1:15 pm-2:15 pm	Session-3 2:15 pm-3:30 pm	Closing Session 3:00 pm-4:00 pm
	29th May, 2023	**Module 1** **mWater App/Portal**	• Welcoming Remarks • Participant Introduction • Module Overview • Expectations from Module	• Introduction to M-Water App • Downloading and Installation of M-Water App **Practical Activity** • Data collection using mWater App in field related to Leakage repair work		**Hands-On Exercise** • Case study regardiing various mWater forms alresdy in use in different WASAs • Creation and customization of Data Collection Form in M-Water Portal		**Hands on Exercise** • Introduction to DashBoard Feature in mWater Portal • Creation of Dashboard in mWater Portal • Use of filter in Excel to analyze data for pipe repalcement	• Formative Quiz • Conclusion on Day's Activities
2	**30th May, 2023**	**Module 2** **QGIS**	• Recap of previous Day Activities • Contents & objectives of the course • Expectations from Module	• Knowledge Sharing Q-GIS by WASA Lahore (Visiting Faculty) **Hands on Exercise** • Introduction to QGIS • Using different features of QGIS • Types of Data input in QGIS		**Hands on Exercise** • Extracting data from mWater portal in excel Format • Importing mWater data in QGIS • How to Visualize Leakage Repair Data in QGIS • Analysis of Data in QGIS		• How to create shapfile in QGIS and its utiliziation in Pipe Repalcement Planning	• Formative Quiz • Conclusion on Day's Activities
3	**31st May, 2023**	**Module 3** **EPANET**	• Recap of previous Day Activities • Contents & objectives of the course • Expectations from Module	**Hands on Exercise** • Introduction to EPANET software • Importance of EPANET • Steps in using EPANET software • Understanding the layout and different features of EPANET		• Knowledge Sharing of Pipe Replacement Planning by WASA Lahore (Visiting Faculty) **Hands on exercise** •Creating a water network model in EPANET • Use of EPANET in Pipe Replacement • Comparison of data received related to pressure, head etc. from EPANET simulation with actual data collected from the model.		**Hands on exercise** • Creating a water supply system in EPANET • Formative Quiz • Conclusion on Day's Activities	Certificate Distribution Group Photo

Chief Advisor: Dr. Sato

Japanese Expert: Mr. Kinno, Mr. Kayanoma

Course Lead :Engr. Rebia Suhail

Course Team: Engr. Muhammad Uzair Safdar, Muhammad Mujahid

Annex 5.1.45 Time Schedule for Training in Fall 2023

LEAKAGE CONTROL, PLUMBING & PIPE REPLACEMENT PLAN

Training Schedule (JICA Phase-II) 2023

Sr. No.	Day & Date	Module Name	Introductory Session 09:30 am-9:45 am	Session-1 9:45 am-10:45 am	Tea Break 10:45 am-11:00 am	Session-2 11:00 am-12:00 am	Session-2 12:00 am - 1:00 pm	Lunch & Prayer Break 1:00 pm-2:00 pm	Session-3 2:00 pm-3:30 pm	Closing Session 3:30 pm-4:00 pm
1	Wednesday 18th OCT, 2023	**Module 1** **MWater**	• Welcoming Remarks • Participant Introduction • Module Overview • Expectations from Module	**Hands-On Exercise** • Introduction to M-Water App • Downloading and Installation of M-Water App/Portal • Application of the Data Collection Form in Actual Repair Works al Activity on M-Water		**Hands on Activity on M-Water** • Creation and customization of Data Collection Form in M-Water Portal • Analysis of data collected using mwater for effctive pipe repalcement planning			**Case study** **Guest lecturer Mr. Nadeem from WASA-Multan** **Share the experience and knowledge of mWatre.** ・Water leakage record ・Costumer survey Based on the collected data how to analyse and use for futter pipe network plan.	• Questionaries • Conclusion on Day's Activities
2	Thursday 19th OCT, 2023	**Module 2** **Pip Replacement Planning**	• Module Overview • Expectations from Module	**Pipe network Model** • Demonstration of Pipe Network Model • Name of each component and its role on pipe network model		**Practical Activity** EPANET Introduction to EPANET software –Interface			**How to use EPANET for the calculation of water pressure and volume properly as pe water demand.** Compare the acttual values with EPA NET Software values.	• Questionaries • Conclusion on Day's Activities
3	Friday 20th OCT, 2023	**Module 3** **Leakage Control**	• Module Overview • Expectations from Module	Hands-On Exercise ・ Introduction to NRW and its causes ・How to prevent and reduce Water Leakage ・The procedure of water leakage detection		**Practical Activity** Leakage survey at site ・The introduction of leakage detection equipment ・How to use leakage equipment ・Try to find actual leakage ・To record the data by mWater on site	**Certificate Distribution** **Group Photo**			

Chief Advisor: Dr. Sato

Japanese Expert: Mr. KAYANOMA

Course Lead :Engr. Rebia Suhail

Course Team: Engr. Syed Fahad Hussain, Engr. Farhan Riaz Engr. Uzair Safdar, Muhammad Mujahid

O&M of Electrical and Mechanical Equipment

21-23/NOV/2023

Training Schedule

Sr. No.	Day & Date	09:00 AM - 10:00 AM	10:00 AM - 11:00 PM		11:15 AM - 12:00 PM	12:00 PM - 01:00 PM		02:00 PM - 03:00 PM
1	21-Nov-23	**Orientation Session** - Introduction and Icebreaking - Expectations from Training -Introduction to MCU -Types of Control Panels	**Introduction to Different components of MCU** **-Introduction to Motor Starters** **-Single Line Diagram for Electrical Circuits** **-Causes and Effects of low Power Factor**	**Tea Break**	**Hands on Activity on Commissioning of a basic MCU** -Connections of Magnetic Contactor, Push Buttons and Protective Relay -Connections of a DOL Starter		**Lunch Break**	**-Cable sizing and equipment (MCCB, MCB, Contactors Sizing)**
2	22-Nov-23	**Orientation Session** - Introduction to performance measuring tools (Flow meter, Vibrometer, etc) - Parameters of Hands-on Activity	**Operation and Maintenance of Pump and induction motor** **-Operation Data Tube well and Disposal Station** **-Link for record keeping by use of mWater application**		**Hands-on Activity on Miniature Pumping Station** - Typical components of pump facility - Hydraulic parameters (Flow Rate, Discharge Pressure, Total Head) - Parallel & series pump operation - Flow and Current Correlation - Pump performance curve (Relationship between flow and discharge pressure) - Comparison of Ultrasonic Flow Meter with Velocity type Water Meter			**Energy Audit Activity on miniature pumping station** - Electrical Parameters of Energy Audit & fill the form on mWater app - Mechanical Parameters of Energy Audit & fill the form on mWater app - Exercise of Vibration - Draw QH Curve on Excel
3	23-Nov-23	**Last Day's Wrap-up** - How to prepare Energy Audit Report - Energy Assesment Tool - Data collection and Analysis using Excel - Energy benchmarking	**Energy Audit by KSB Team** **Introduction to Reverse Engineering Method**					**Prepration of Maintenance Plan for Facility** (Process Improvement, Operations Optimization, Efficiency Planning) **Feedback on topics for upcoming training & Closing Ceremony**

Operation & Maintenance of Sewerage and Drainage System
Training Schedule (JICA Phase-II) December 2023

Sr. No.	Day and Date	Module Name	Session-1			Tea 11:00 am-11:20 am	Session-2	Lunch 1:00 pm-2:00 pm	Session-3	
			09:30 am-9:45 am	9:45 am-10:15 am	10:15 am-11:00 am		11:20 am-01:00 pm		2:00 pm-3:00 pm	3:00 pm-3:30 pm
1	Tuesday 12 December 2023	Module 01 **Cleaning of Sewerage & Drainage Pipelines**	• Welcoming Remarks • Participant Introduction • Pre Evaluation • Course Overview **(JICA Expert)**	• Inspection of Sewers & Manholes • Introduction to Sewer Camera (Parts + Working) **(Mr. Fahad)**		**Tea Break**	**FIELD WORK** • Sewer / Manhole Inspection with Camera (Public Awareness to Children Regarding Overflow from Sewer) **(Mr. Fahad)**	**Lunch & Prayer Break**	• Introduction to mWater App • Installation of mWater App / Portal **(Mr. Uzair)**	• Quick Win Measures (QWMs) • Conclusion on Day's Activities
2	Wednesday 13 December 2023	Module 02 **Data Analysis mWater**	• Recap of Previous Day Activities	• Creation & Customization of Crown Failure Data Collection Form in mWater Portal **(Mr. Uzair)**			• Analysis of Crown Failure Data on mWater Portal • Analysis of Data in QGIS **(Mr. Uzair)**		**Guest Lecturer** **(Mr. Nadeem - WASA Multan)** • Share the Experience of Crown Failures in Multan • Identification of Root Causes Based on Historical mWater Data • Remedial Measures & Future Planning	
3	Thursday 14 December 2023	Module 03 **Field Activities**	• Recap of Previous Day Activities	**FIELD WORK** • Use of Metal Locator (Academy Premises) **Mr. Irfan / Mr. Fahad**			**Guest Lecturer** **(Mr. Mehdi - WASA Lahore)** • Sludge Estimation of Drain Calculation using mWater (Current Practice in WASA Lahore)		• Post Evaluation • Reflections • Group Picture • Certificates	

JICA Experts : Dr. Noboyuki Sato, Mr. Tomidokoro
Course Team: Engr. Syed Fahad Hussain, Engr. Muhammad Irfan, Engr. Uzair Safdar

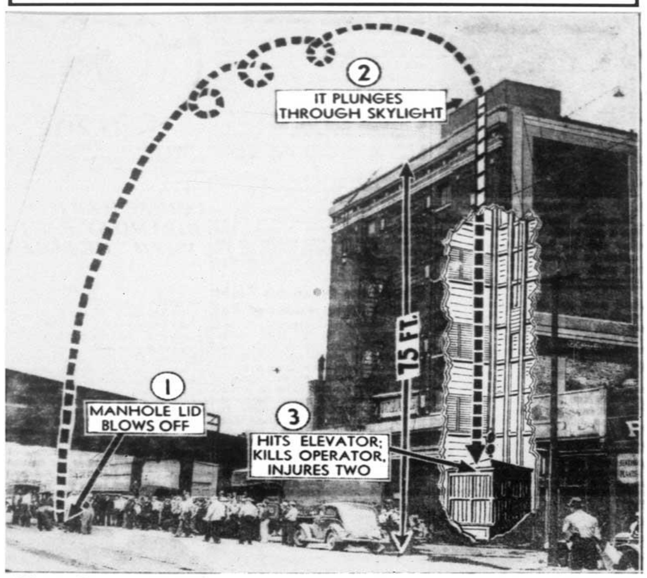
Annex 5.1.46 Training Material for "O&M of Sewerage and Drainage" in Summer 2022

Starter

May, 1937

CHICAGO SUNDAY TRIBUNE: MAY 30, 1937

ONE KILLED WHEN BLAST FLIPS MANHOLE COVER



When a subterranean explosion tossed many manhole covers on Fullerton avenue into the air yesterday, one of the lids was blown high and crashed down the elevator shaft of the Hollander Storage and Moving company at 2418 Milwaukee avenue, killing the elevator operator, A. C. Day, 57 years old, of 5642 Melrose street Two others on the freight elevator were slightly injured. Dotted line shows missil's path.


Jan, 2013


WGRZ-TV
gorapapo TV

Ice Breaking Session

Candy Color Ideas

Blue : A boss you respected and why?

Green: A reason why you are proud to belong to your organization.?

Orange: An embarrassing moment at work.

Red: Your biggest working success.

Yellow: The funniest moment at work.

Purple: A time at organization where you have failed and, what you learnt from it.

Removal of Blockages in Sewer Lines

Sewer Blockages & Its Types

1 - Sewer Blockage

Any barrier which causes the sewer system plugged and in the result flow backs up

2 -Types of Sewer Blockage

Grease	Roots	Sand	Lost Rods
Debris	Rags	Silt	Plugs
Broken Pipe	Plastic Bags	Ruble	Wooden Posts
Joint Failure	Broken Pipes	Steel Rebar	Barbed Wire
Detergents	Brick	Large Metal	Tree Limbs
Sticks	Rock	Plastic Buckets	Dead Animals

- Structural
- Hydraulic
- People

Sewer Blockages & Its Types

Roots

Grease

Debris

Reasons for Cleaning Sewer & Manhole

1. To <u>remove</u> the obstruction
2. To <u>reduce</u> the complaints regarding the bad odor
3. To <u>minimize</u> the overflow and ponding of sewage

Methods for Sewer & Manhole Cleaning

1) **Manual**
2) **Mechanical**
3) **Hydraulic**

Manual Method

Hand Rodding

Long strips from bamboo stem are taken and tailored to use as sewer cleaning rod between two consecutive manholes

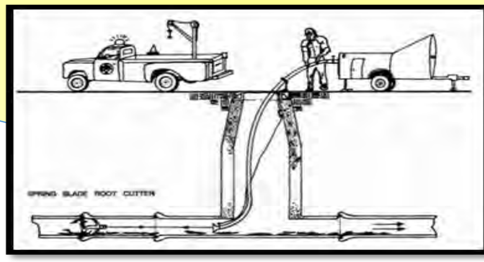
Hand Rodding (Set Up and Procedure)

1. Ventilate the manhole and test for toxic gases, explosive gases, and oxygen level
2. Determine the depth of the manhole
3. Assemble sufficient rod

Mechanical Methods

Power Rodding

- Power rodding machines use a steel rod to push or pull various clearing tools through sewers.
- These machines are of various designs and are equipped with a rod in a reel having lengths up to approximately 1,000 feet.
- This reel can be rotated to give turning action as the rod is pushed in or removed.



Bucket Machine (Winch Machine)

Equipment Set up

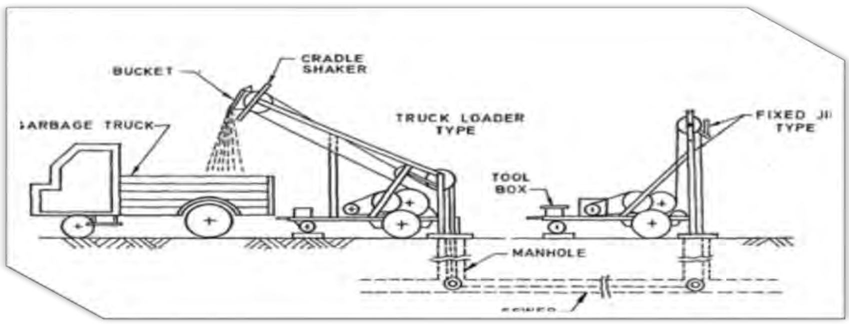
1) Position the two machines over the respective manholes

2) Place the pads under the stabilizer feet of the machine and jack them down. The lower manhole roller is lowered into the manhole.

Bucket Machine (Winch Machine)

Equipment Set up

4) To thread the sewer, a synthetic rope can be used
5) To this rope attach a nylon parachute designed for such use and allow this parachute to float downstream to the working manhole



Bucket Machine (Winch Machine)

Equipment Set up

6) The clearing bucket is now ready to be attached to the cable

7) As the bucket is pulled upstream into the material deposited in the sewer, a definite resistance can be noticed when the bucket is full

8) When the bucket is full, pull the loaded bucket back out of the sewer

9) Final cleanup is performed with special care given to washing down and completely cleaning the entire area

Hydraulic Methods

1 - Flushing

1. Start operation at the upstream end
2. Place the water line over the manhole
3. Clean the manhole first
4. Dumped some of the water
5. Observe any evidence of water backing up
6. Look for signs of grease & roots etc.
7. Close the manhole and go to downstream manhole
8. Repeat from manhole to manhole

2- Jetting and Sucking

The use of hydraulic pressure to de-silt sewers dates back to the early 1900s; however, this method has been developed with the passage of time by using high velocity cleaning machines.

- **High velocity cleaning machines are confidently used to:**
  - **Open Stoppages**
  - **Remove Grease**
  - **Clean lines of Debris**
  - **Wash Manholes and Wet Wells**

Equipment Set up and Operation

Sr. No.	Set up and working
1	Fill the water tank from a fire hydrant close to the area where you will do the cleaning
2	Start at the top or highest point in the collection system
3	Select the appropriate nozzle for the size of pipe to be cleaned
4	Install the proper size sand or debris trap in the downstream manhole
5	Turn the reel directional control to “Out” and lower the hose and cleaning nozzle into the manhole
6	Turn the water valve on and start the high pressure pump

Equipment Set up and Operation

Sr. No.	Set up and working
7	First try 50 feet to check the situation in the sewer
8	By increasing pressure you may be able to go farther
9	Retest the manhole atmosphere for sewer gases to be sure the ventilation procedures are effective
10	Allow an operator properly equipped with a safety harness to enter the manhole and shovel the debris into a bucket which in turn is pulled to the surface with a hand line
11	During all this jetting operation sucking machine will suck all the dislodged silt and debris from the same manhole by a 4 inch hose
12	Sucker will be emptied at drain or some other purpose built area

INSPECTION OF SEWER / MANHOLE

Objectives of Sewer Inspection

- To identify existing or potential problems in Sewer / Manhole
- To examine structural integrity of the Sewer / manhole
- To observe functional capacity of Sewer / manhole
- To generate concise and meaningful reports

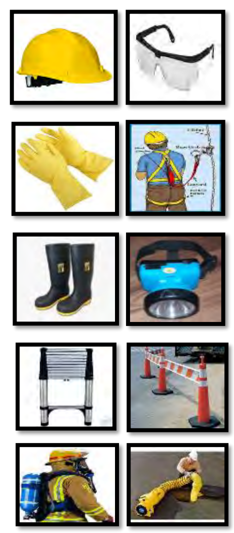
INSPECTION METHODS

- Visual
- Camera

Visual Inspection

Arrangements before Inspection:

• Map of the Collection System	• Scrapers and Wire Brushes for Cleaning the Manhole Ring
• Metal Detector	• Powerful Flashlight
• Warning Devices, Safety Cones and Traffic Safety Devices	• Gas Detection Devices
• Manhole Lid Removal Device	• Blower and Hose for Ventilating Manhole
• Leather Gloves	



Safety Control during Inspection

Categories of Visual Inspection…

Initial Inspection

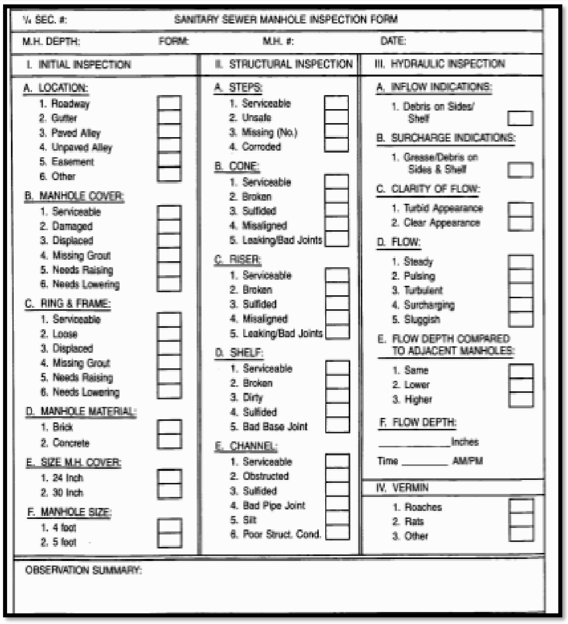
- Location
- Manhole Cover
- Ring & Frame
- Manhole Material
- Sizes

Structural Inspection

- Steps
- Cone
- Riser
- Shelf
- Channel

Hydraulic Inspection

- Inflow
- Clarity
- Flow
- Flow Depth
- Vermin



¼ SEC. #: SANITARY SEWER MANHOLE INSPECTION FORM

M.H. DEPTH: FORM: M.H. #: DATE:

I. INITIAL INSPECTION

A. LOCATION:
1. Roadway
2. Gutter
3. Paved Alley
4. Unpaved Alley
5. Easement
6. Other

B. MANHOLE COVER:
1. Serviceable
2. Damaged
3. Displaced
4. Missing Grout
5. Needs Raising
6. Needs Lowering

C. RING & FRAME:
1. Serviceable
2. Loose
3. Displaced
4. Missing Grout
5. Needs Raising
6. Needs Lowering

D. MANHOLE MATERIAL:
1. Brick
2. Concrete

E. SIZE M.H. COVER:
1. 24 Inch
2. 30 Inch

F. MANHOLE SIZE:
1. 4 foot
2. 5 foot

II. STRUCTURAL INSPECTION

A. STEPS:
1. Serviceable
2. Unsafe
3. Missing (No.)
4. Corroded

B. CONE:
1. Serviceable
2. Broken
3. Sulfided
4. Misaligned
5. Leaking/Bad Joints

C. RISER:
1. Serviceable
2. Broken
3. Sulfided
4. Misaligned
5. Leaking/Bad Joints

D. SHELF:
1. Serviceable
2. Broken
3. Dirty
4. Sulfided
5. Bad Base Joint

E. CHANNEL:
1. Serviceable
2. Obstructed
3. Sulfided
4. Bad Pipe Joint
5. Silt
6. Poor Struct. Cond.

III. HYDRAULIC INSPECTION

A. INFLOW INDICATIONS:
1. Debris on Sides/ Shelf

B. SURCHARGE INDICATIONS:
1. Grease/Debris on Sides & Shelf

C. CLARITY OF FLOW:
1. Turbid Appearance
2. Clear Appearance

D. FLOW:
1. Steady
2. Pulsing
3. Turbulent
4. Surcharging
5. Sluggish

E. FLOW DEPTH COMPARED TO ADJACENT MANHOLES:
1. Same
2. Lower
3. Higher

F. FLOW DEPTH:
________ Inches
Time ________ AM/PM

IV. VERMIN
1. Roaches
2. Rats
3. Other

OBSERVATION SUMMARY:

Manhole Inspection Form

Screening Camera For Sewer Culvert Inspection

Objectives of Screening Camera

- To look for damages / breaks in sewer line
- To locate root intrusion
- To find unrecorded connection
- To locate protruding laterals
- To locate cracks / inflow sources
- To search lost / buried lines
- To verify alignment

Components of Camera

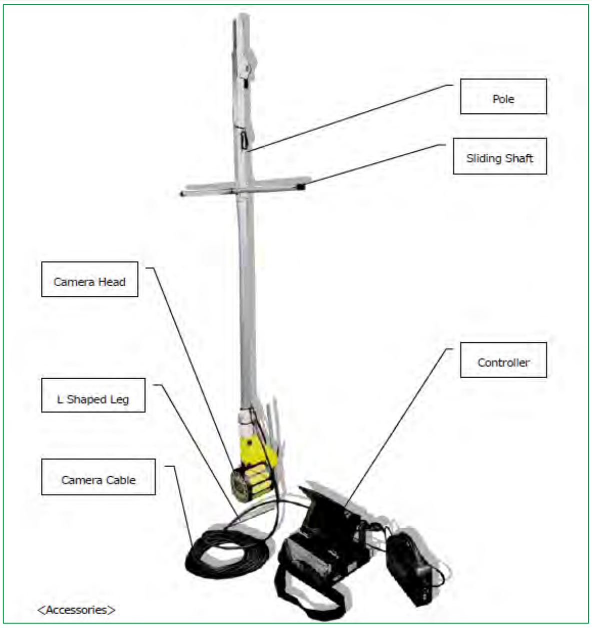
System

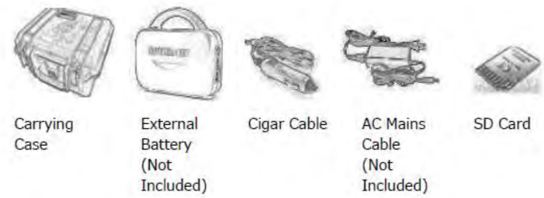
1)	Camera Head	··········· 1 pc
2)	Camera Cable (10m)	··········· 1 pc
3)	Controller	··········· 1 pc
4)	Pole (4.5m : 3-stage telescopic)	··········· 1 pc

Accessories

1)	Carrying Case	··········· 1 pc
2)	SD Card	··········· 1 pc
3)	Cigar Cable	··········· 1 pc
4)	AC Mains Cable	··········· 1 pc
5)	Instruction Manual (this document)	··········· 1 pc

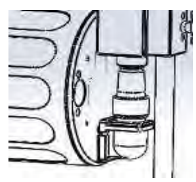
Components of Camera

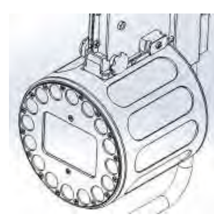




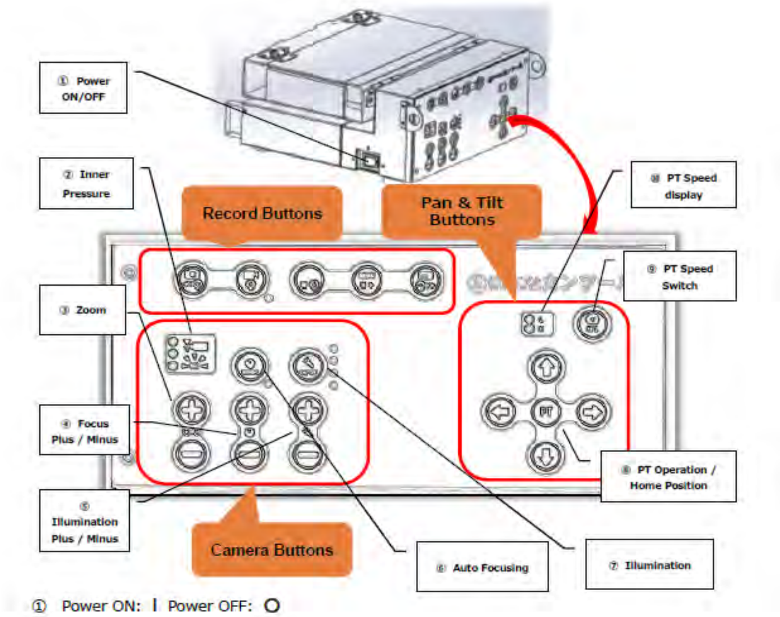
How to Connect Device

- Take out the camera head and the camera cable from the carrying case.
- Connect the camera head to the camera cable
- Take out the controller from the carrying case.
- Connect the controller to the camera cable.
- Connect the pole to the camera head





How to Operate (Overview)



WASA Rawalpindi (Pictures)

Contacts:

Name	Designation	Contact No.	E-Mail
Mr. Tomidokoro	JICA Expert		
Mr. Muhammad Irfan	Course Leader	+92-(0)321-4890151	cemis2010@gmail.com
Mr. Wajih	JICA Coordinator		
Mr. Syed Fahad Hussain	Project Officer	+92-(0)332-4461657	fahadshah407@gmail.com

Cleaning Techniques of
Sewerage & Drainage System

Sewer Cleaning Equipment

1. Split Bamboo Cane
2. Steel Rod
3. Power Rodder
4. Sewer Ball or Tire
5. High Pressure Water Jetting Machine
6. Sucker Machine
7. Bucket Machine (Winch Machine)

Sewer Cleaning Equipment

1 - Split Bamboo Cane

Hand Rodding

- ✓ Oldest Method
- ✓ Torque by Hand

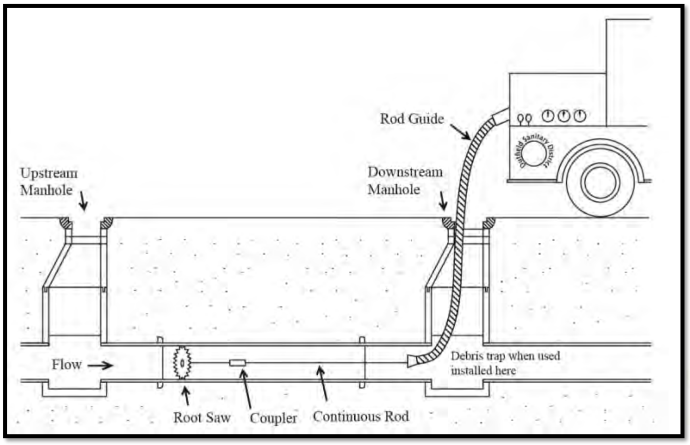
2 - Steel Rod

Hand Rodding

Torque by Hand

3 - Power Rodder

Torque by Engine



3 - Power Rodder

Advantages

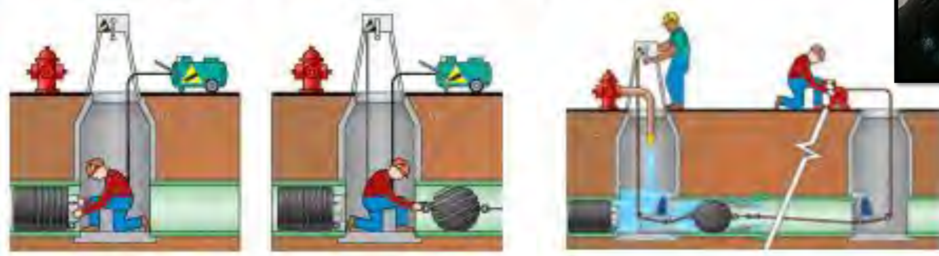
- To cut roots
- Scrape, dislocate and remove certain material
- Effective in removing emergency stoppages

Limitations

- Ineffective for removing sand and grit, but may loosen material
- Rods have a tendency to coil and bend

4 - Sewer Ball or Tire

Cleaning Ball Application



1. Install Plug to isolate manhole.
2. Attach Ball to tag line and inflate.
3. Introduce water into manhole and slowly release Ball down the line.

5- High Pressure Water Jetting Machine

Jetting Machine Nozzles …




High Pressure Water Jetting Machine

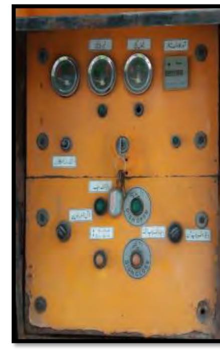
Advantages

- Very effective in cleaning flat, slow flowing sewers
- Efficient in removing grease, sand, gravel and debris
- Can be used to remove emergency stoppages

Limitations

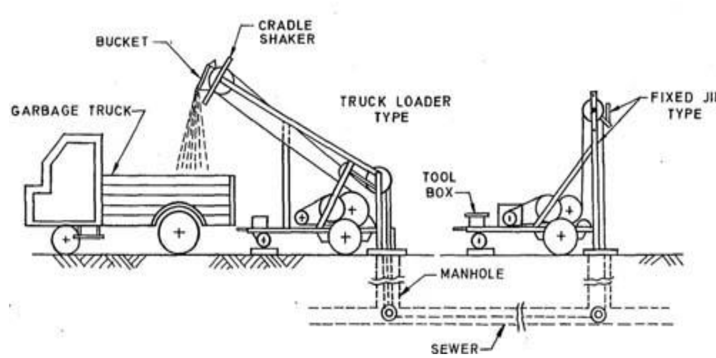
- Effectiveness in take out debris from larger diameter lines decrease as the cross-sectional area of the pipe is increased

6- Sucker Machine



Courtesy – WASA Green Town Sub-Division

6 -Bucket Machine (Winch Machine)



Bucket Machine

Advantages

- Efficient in removing sand, gravel, and debris

Limitations

- Can damage pipe line internally
- Setting up equipment is time taking activity

Care & Maintenance of Equipment

Objectives

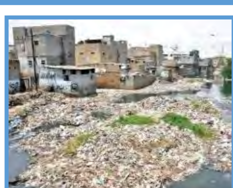
- To keep equipment in good condition to help prevent equipment failure on the job
- To prolong the lifespan of the equipment
- To enhance the efficiency and safety at maintenance jobs

General Maintenance of Equipment Engines

1. Always be sure **oil and water levels** are in proper range.
2. Use a fresh supply of the proper grade of **clean diesel.**
3. Change **oil and air filters** according to manufacturer's recommendations.
4. Exercise **(operate)** equipment weekly.
5. Use **proper type of oil** in engines, transmission and for lubrication.
6. Keep **battery terminals** clean and battery charged, especially during winter.

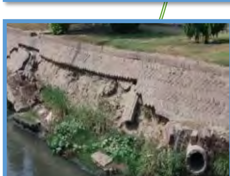
Basics of Drainage System

Critical Issues



Encroachment of drains

Silting of drains due to constant blockages



Stability of drainage cross-sections dislocated and damaged old lining of the drains

Critical Issues

- Unpleasant odor of dirty water flowing in the drains
- Absence of comprehensive data on storm-water drainage network
- Inadequate attention to cleaning of natural drains and clearance of excess floral growth on the drains
- Free access to dispose wastewater from nearby habitation

O&M of Drainage System

Departments should devise maintenance procedures including:

- Frequency of inspection
- Programme for dredging
- Necessary repair works
- Documentation for maintenance records

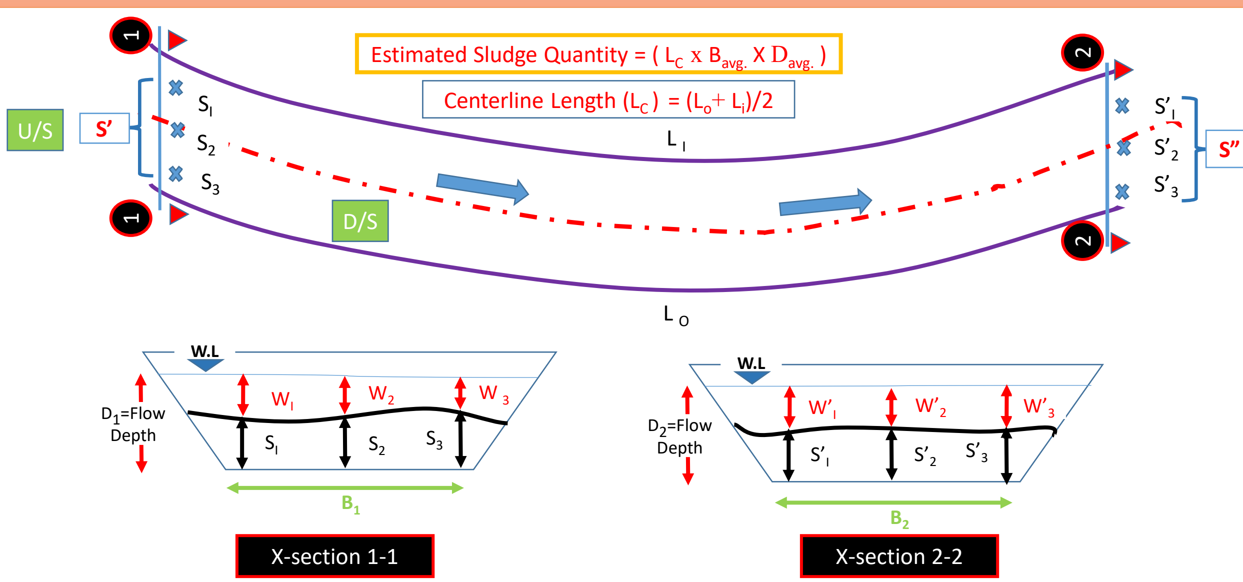
Measurement of Sludge Quantity in Drains

Foot Bridge 01

Foot Bridge 02

Maulana Shaukat Ali Drain (Secondary Type)

Sketches (Layout and X-Section)



Sludge Volume Calculation

Depth at Foot 1 $S_n = (D - W_n)$		Avg. Depth at Foot 1 S_{avg}	Depth at Foot 2 $S_n = (D - W_n)$		Avg. Depth at Foot 2 S'_{avg}	Overall Avg. Depth D_{avg}	Width at Foot 1 B_1	Width at Foot 2 B_2	Avg. Width B_{avg}	Length Inner L_i	Length Outer L_o	L_c	Sludge Volume V
S_1			S'_1										
S_2			S'_2										
S_3			S'_3										

D_1=

D_2=

Estimated Sludge Quantity (Vol.)

$= (L_C \text{ X } B_{avg.} \text{ X } D_{avg.})$

CUM or CFT

Estimated Sludge Quantity (Vol)

= (X   X   )

CUM or CFT

$L_C = (L_O + L_I) / 2$ (if drain stretch is curved)

$S' = (S_1 + S_2 + S_3 + \ldots) / n$

$S'' = (S'_1 + S'_2 + S'_3 + \ldots) / n$

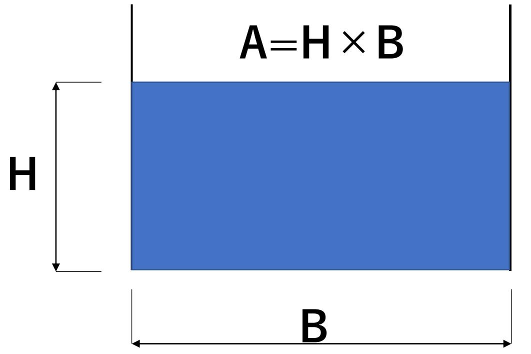
$D_{avg.} = (S' + S'' + S''' + \ldots) / n$

$B_{avg.} = (B_1 + B_2 + B_3 + \ldots) / n$

Flow measurement of Open Channels

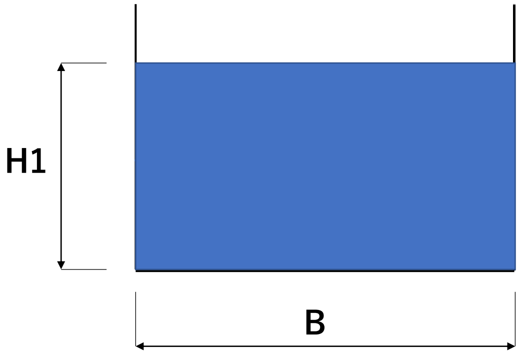
$Q = A * V$

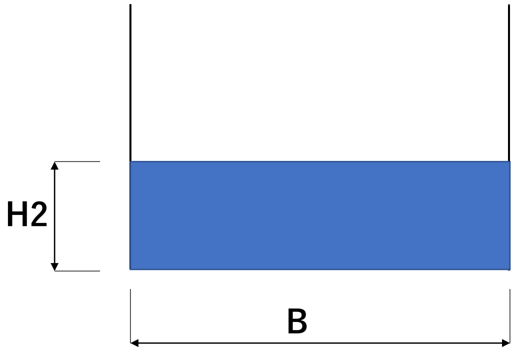
- Q : flow rate
- A : Area
- V : Velocity



Open Channel : Area & Velocity

1) Area

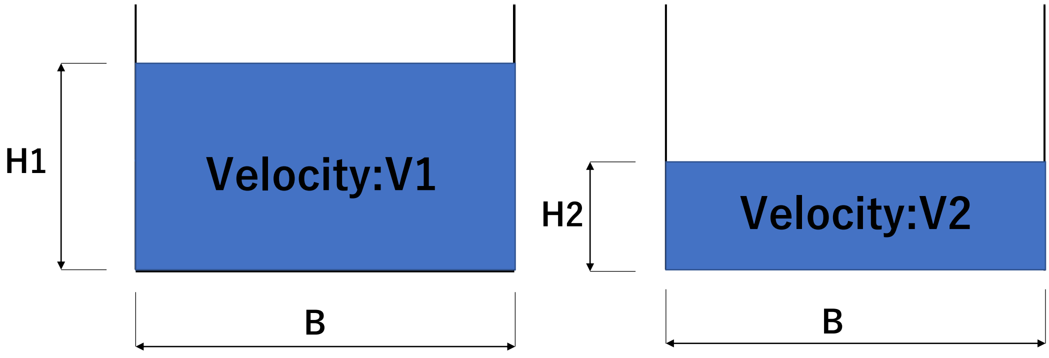




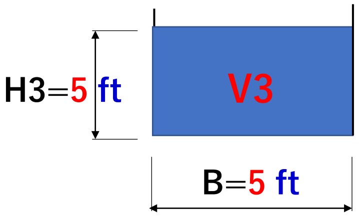
$A1 = H1 \times B$

$A2 = H2 \times B$

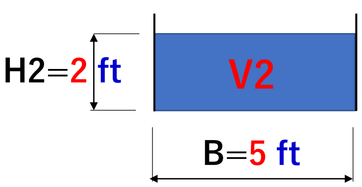
2) Velocity



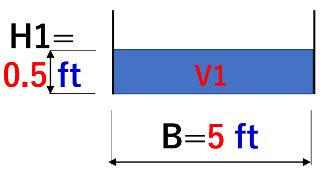
※ Flow velocity depends on the water level position to be measured.



A3=5*5＝25 ft2
V3=4.36 ft/s
Q3=25*4.36
=109 ft3/s
(cusec)

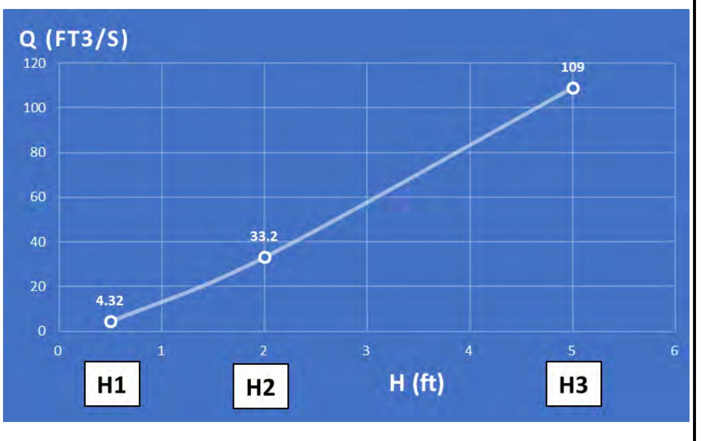


A2=5*2＝10 ft2
V2=3.32 ft/s
Q2=10*3.32
=33.2ft3/s
(cusec)



A1=5*0.5＝2.5
ft2
V1=1.73 ft/s
Q1=2.5*1.73
=4.32 ft3/s
(cusec)

H-Q(Height-Quantity) Curve



※ft3/s＝cusec

Measurement of Discharge in Channel / Drain

Left	cm/s	Center	cm/s	Right	cm/s
V1		V4		V7	
V2		V5		V8	
V3		V6		V9	
Avg.		Avg.		Avg.	

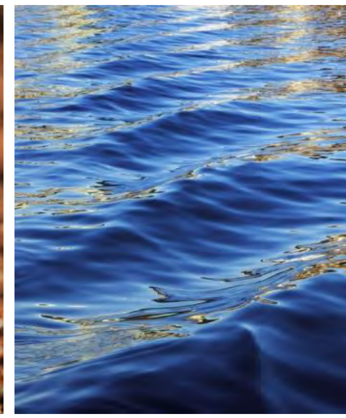
Marks	25	
	m	ft
Width		
Depth		

Avg of 9 Points (cm/s)	
Avg of 9 Points (m/s)	
Avg of 9 Points (ft/s)	

Q = A X V	

Name	
Designation	
Organization	
Obtained Marks	

Wastewater Treatment Module 3 & 4



Contents

This module is comprise of five lectures:

- Basics of Wastewater
- Wastewater Treatment Technologies
- Maintenance of Ponds
- Financial Comparison Technology
- Selection of Treatment Technology

Instructional goals

- Basics characteristics of wastewater
- Compare different wastewater treatment technologies
- Choose correct treatment Technologies
- How to remove sludge from ponds?

Instructional Method

- Power point presentation
- Videos
- Quiz
- Lab Test

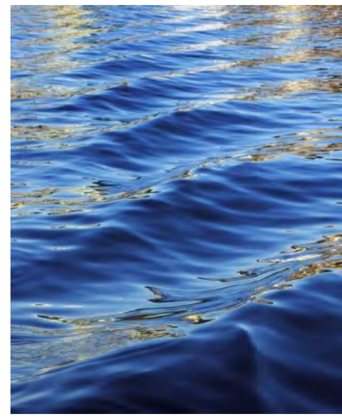
Pre Evaluation Activity

- https://jamboard.google.com/d/19YQrEkkieKRQmkVH7ywNnndWdLv8wEM0c8g6qEcmu0E/viewer?f=0

Learning Outcomes

- <u>Compare</u> different **wastewater treatment technologies**
- <u>Understand</u> the procedure of **selecting** suitable technology
- <u>Estimate</u> Initial Cost (**Capex**) & Operational Cost (**Opex**) of different wastewater treatment technologies
- <u>Understand</u> the procedure of **sludge removal** from Ponds

Basics of Wastewater



Wastewater

Source of Wastewater

- Domestic
- Agriculture
- Industrial

Wastewater Characterization

PHYSICAL

CHEMICAL

BIOLOGICAL

Wastewater Characterization

PHYSICAL
- TSS
- pH
- TEMPERATURE
- COLOR
- ODORS
- TURBIDITY

CHEMICAL
- COLOR
- FATS & GREASE
- COD
- NITROGEN & PHOSPHORUS
- SURFACTANTS
- PHENOLS
- CHEMICALS
- SULFUR
- HEAVY METALS

BIOLOGICAL
- BOD
- OXYGEN RQUIRED FOR NITRIFICATION
- MICROBIAL POPULATION

Wastewater Characterization

PHYSICAL
- TSS
- pH
- TEMPERATURE
- COLOR
- ODORS
- TURBIDITY

CHEMICAL
- COLOR
- FATS & GREASE
- COD
- NITROGEN & PHOSPHORUS
- SURFACTANTS
- PHENOLS
- CHEMICALS
- SULFUR
- HEAVY METALS

BIOLOGICAL
- BOD
- OXYGEN RQUIRED FOR NITRIFICATION
- MICROBIAL POPULATION

Wastewater Characterization

PHYSICAL
- TSS
- pH
- TEMPERATURE
- COLOR
- ODORS
- TURBIDITY

CHEMICAL
- COLOR
- FATS & GREASE
- COD
- NITROGEN & PHOSPHORUS
- SURFACTANTS
- PHENOLS
- CHEMICALS
- SULFUR
- HEAVY METALS

BIOLOGICAL
- BOD
- OXYGEN RQUIRED FOR NITRIFICATION
- MICROBIAL POPULATION

Biochemical Oxygen Demand

BOD represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic (oxygen is present) conditions at a specified temperature

PACK Test Procedure

1.

Pull out the line at the end of the tube

2.

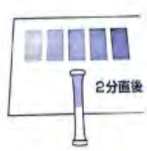
With the hole up, pinch the bottom half of the tube tightly with your finger and push out the air inside

PACK Test Procedure

3.

Continue to place the hole in the test water, loosen the pinching fingers, and wait until half of the water is absorbed. Shake the tube gently 15 times to prevent leakage

4.



Immediately after 2 minutes, place the tube on top of the standard color and compare the colors.

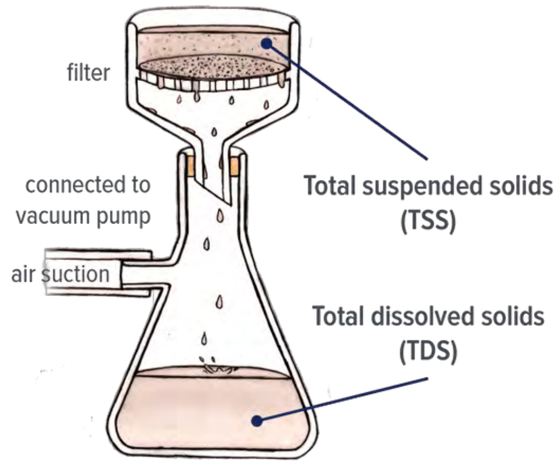
Chemical Oxygen Demand

The chemical oxygen demand is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution.

It is commonly expressed in mass of oxygen consumed over volume of solution which in SI units is milligrams per liter.

Total Suspended Solids

Total Suspended Solids (TSS) are **solids in water that can be trapped by a filter**. TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage.



Wastewater NEQs

S.No	Parameter	Existing Standards	Revised Standards		
			Into Inland Water	Into Sewage Treatment[5]	Into Sea[6]
1.	Temperature or Temperature increase*	40°C	=<3 °C	=< 3 °C	=<3 °C
2.	pH value	6-10 pH	6 - 9	6 - 9	6 - 9
3.	5-days Biochemical Oxygen Demand (BOD_1) at 20°C[1]	80 mg/l.	80	250	80**
4.	Chemical Oxygen Demand (COD)[1]	150 mg/l.	150	400	400
5.	Total suspended solids	150 mg/l.	200	400	200
6.	Total dissolved solids	3500 mg/l.	3500	3500	3500
7.	Grease and oil	10 mg/l.	10	10	10
8.	Phenolic compounds (as phenol)	0.1 mg/l.	0.1	0.3	0.3
9.	Chloride (as Cl)	1000 mg/l.	1000	1000	SC
10.	Fluoride (as F)	20 mg/l.	10	10	10
11.	Cyanide (as CN) total	2 mg/l.	1.0	1.0	1.0
12.	An-ionic detergents[2] (as MBAS)	20 mg/l.	20	20	20
13.	Sulphate (SO_4)	600 mg/l.	600	1000	SC
14.	Sulphide (S)	1.0 mg/l.	1.0	1.0	1.0
15.	Ammonia (NH_3)	40 mg/l.	40	40	40
16.	Pesticides, herbicides, fungicides and insecticides[3]	0.15 mg/l.	0.15	0.15	0.15

THANK YOU

Financial Comparison of WWT Technologies

Case Studies

Technology	Volume	Unit	Capital Cost	Unit	Land Requirement	Unit	Annual Operation & maintenance Cost (US $/P.E)	Country
Activated Sludge Process	20,000–400,000	(m3/d)	50.0–60.8	(US $/m3/d)	0.73–1.01	(m2/m3/d)		India
Waste Stabilization Ponds	20,000–400,000	(m3/d)	12.4–18.0	(US $/m3/d)	12.5–14.0	(m2/m3/d)		India
Waste Stabilization Ponds	50,000	P.E	35.6	(US $ /PE)	1.7	(m2/P.E)	0.53	Egypt
UASB + Trickling filters	50,000	P.E	31.5	(US $ /PE)	0.22	(m2/P.E)	0.71	Egypt

Technology Comparison – Capex & Opex

DESCRIPTION	ASP-EA	MBR	UF	RO
pH	7.0-8.5	7.0-8.5	7.0-8.5	5.8-6.2
BOD, mg/l	<30	<5	<5	<5
COD, mg/l	<100	<15	<15	<5
TSS, mg/l	<30	BDL	BDL	BDL
Area, m^2/m^3 of Wastewater	25	13		
Civil Cost , Rs. in Million / m^3	0.8-1.0	0.4-0.5		
Equipment/ Plant Cost , Rs. in Million / m^3	0.7-0.9	1.5 – 1.6	0.4 - 0.5	0.30 - 0.35
Power Cost , Rs. / m^3 @ Rs. 14.0 / kW - HR	23.2	45.2	7.7	12.97
Chemical Cost , Rs. / m^3	10.8	9.1	0.6	7.6
Membrane Replacement Rs. / m^3 (Average Life 3 Years)		15.3	4.0-8.0	5.6
Membrane Replacement Rs. / m^3 (Average Life 5 Years)		9.2	2.2-4.8	3.4

Above Case Study is based on wastewater influent characteristics ,

pH: 8, BOD : 1400 mg/l , COD : 3500 mg/l , TSS : 700 mg/l and Flow : 50 m^3/ hr.

THANK YOU

Selection of Treatment Technology

FACTORS OF CHOICE IN WASTE TREATMENT METHODS

Affordability

Depends on the financial ability of the community

Requirement of the process in term of power and land

FACTORS OF CHOICE IN WASTE TREATMENT METHODS

Acceptability

Depends upon performance of the treatment system

Pollution control authority (EPAs or DAs)

Riparian public

FACTORS OF CHOICE IN WASTE TREATMENT METHODS

Manageability

Refers to routine operation of the plant and its maintenance and repair

Will it be possible to repair the machinery locally

Activated Sludge	Aerated Lagoons	Waste Stabilization Ponds
High CAPEX	Low CAPEX	Lowest CAPEX
High initial cost and complex, expensive ongoing energy & operations costs	Low initial cost and lower ongoing energy & operations costs	Low initial cost and low ongoing energy & operations costs, but several common problems
Shock & Peak Loads Can Upset Process	Easily Accepts Shock & Peak Loads	Problems With Shock & Peak Loads
Prescreening Equipment Generally Required	No Prescreening Equipment Required	No Prescreening Equipment Required
Aeration Required for Both Oxygen & Mixing	Aeration Required only for Oxygen Demand	No Aeration used for Oxygen Demand
Can Have Odor Issues	Odor-Free WWTP	Can Have Odor Problems
Sludge Handling & Regulation Required	Possible Future Sludge Removal Required	Possible Future Sludge Removal Required
High Consumables/Chemicals	Few Consumables/Chemicals	No Consumables/Chemicals
High Level of Operator	Very Low Operator Attention/Expertise	Very Low Operator Attention/Expertise

Activated Sludge	Aerated Lagoons	Waste Stabilization Ponds
High CAPEX	Low CAPEX	Lowest CAPEX
High initial cost and complex, expensive ongoing energy & operations costs	Low initial cost and lower ongoing energy & operations costs	Low initial cost and low ongoing energy & operations costs, but several common problems
Shock & Peak Loads Can Upset Process	Easily Accepts Shock & Peak Loads	Problems With Shock & Peak Loads
Prescreening Equipment Generally Required	No Prescreening Equipment Required	No Prescreening Equipment Required
Aeration Required for Both Oxygen & Mixing	Aeration Required only for Oxygen Demand	No Aeration used for Oxygen Demand
Can Have Odor Issues	Odor-Free WWTP	Can Have Odor Problems
Sludge Handling & Regulation Required	Possible Future Sludge Removal Required	Possible Future Sludge Removal Required
High Consumables/Chemicals	Few Consumables/Chemicals	No Consumables/Chemicals
High Level of Operator	Very Low Operator Attention/Expertise	Very Low Operator Attention/Expertise

Activated Sludge	Aerated Lagoons	Waste Stabilization Ponds
High CAPEX	Low CAPEX	Lowest CAPEX
High initial cost and complex, expensive ongoing energy & operations costs	Low initial cost and lower ongoing energy & operations costs	Low initial cost and low ongoing energy & operations costs, but several common problems
Shock & Peak Loads Can Upset Process	Easily Accepts Shock & Peak Loads	Problems With Shock & Peak Loads
Prescreening Equipment Generally Required	No Prescreening Equipment Required	No Prescreening Equipment Required
Aeration Required for Both Oxygen & Mixing	Aeration Required only for Oxygen Demand	No Aeration used for Oxygen Demand
Can Have Odor Issues	Odor-Free WWTP	Can Have Odor Problems
Sludge Handling & Regulation Required	Possible Future Sludge Removal Required	Possible Future Sludge Removal Required
High Consumables/Chemicals	Few Consumables/Chemicals	No Consumables/Chemicals
High Level of Operator	Very Low Operator Attention/Expertise	Very Low Operator Attention/Expertise

Activated Sludge	Aerated Lagoons	Waste Stabilization Ponds
High CAPEX	Low CAPEX	Lowest CAPEX
High initial cost and complex, expensive ongoing energy & operations costs	Low initial cost and lower ongoing energy & operations costs	Low initial cost and low ongoing energy & operations costs, but several common problems
Shock & Peak Loads Can Upset Process	Easily Accepts Shock & Peak Loads	Problems With Shock & Peak Loads
Prescreening Equipment Generally Required	No Prescreening Equipment Required	No Prescreening Equipment Required
Aeration Required for Both Oxygen & Mixing	Aeration Required only for Oxygen Demand	No Aeration used for Oxygen Demand
Can Have Odor Issues	Odor-Free WWTP	Can Have Odor Problems
Sludge Handling & Regulation Required	Possible Future Sludge Removal Required	Possible Future Sludge Removal Required
High Consumables/Chemicals	Few Consumables/Chemicals	No Consumables/Chemicals
High Level of Operator	Very Low Operator Attention/Expertise	Very Low Operator Attention/Expertise

Activated Sludge	Aerated Lagoons	Waste Stabilization Ponds
High CAPEX	Low CAPEX	Lowest CAPEX
High initial cost and complex, expensive ongoing energy & operations costs	Low initial cost and lower ongoing energy & operations costs	Low initial cost and low ongoing energy & operations costs, but several common problems
Shock & Peak Loads Can Upset Process	Easily Accepts Shock & Peak Loads	Problems With Shock & Peak Loads
Prescreening Equipment Generally Required	No Prescreening Equipment Required	No Prescreening Equipment Required
Aeration Required for Both Oxygen & Mixing	Aeration Required only for Oxygen Demand	No Aeration used for Oxygen Demand
Can Have Odor Issues	Odor-Free WWTP	Can Have Odor Problems
Sludge Handling & Regulation Required	Possible Future Sludge Removal Required	Possible Future Sludge Removal Required
High Consumables/Chemicals	Few Consumables/Chemicals	No Consumables/Chemicals
High Level of Operator	Very Low Operator Attention/Expertise	Very Low Operator Attention/Expertise

Activated Sludge	Aerated Lagoons	Waste Stabilization Ponds
High CAPEX	Low CAPEX	Lowest CAPEX
High initial cost and complex, expensive ongoing energy & operations costs	Low initial cost and lower ongoing energy & operations costs	Low initial cost and low ongoing energy & operations costs, but several common problems
Shock & Peak Loads Can Upset Process	Easily Accepts Shock & Peak Loads	Problems With Shock & Peak Loads
Prescreening Equipment Generally Required	No Prescreening Equipment Required	No Prescreening Equipment Required
Aeration Required for Both Oxygen & Mixing	Aeration Required only for Oxygen Demand	No Aeration used for Oxygen Demand
Can Have Odor Issues	Odor-Free WWTP	Can Have Odor Problems
Sludge Handling & Regulation Required	Possible Future Sludge Removal Required	Possible Future Sludge Removal Required
High Consumables/Chemicals	Few Consumables/Chemicals	No Consumables/Chemicals
High Level of Operator	Very Low Operator Attention/Expertise	Very Low Operator Attention/Expertise

Activated Sludge	Aerated Lagoons	Waste Stabilization Ponds
High CAPEX	Low CAPEX	Lowest CAPEX
High initial cost and complex, expensive ongoing energy & operations costs	Low initial cost and lower ongoing energy & operations costs	Low initial cost and low ongoing energy & operations costs, but several common problems
Shock & Peak Loads Can Upset Process	Easily Accepts Shock & Peak Loads	Problems With Shock & Peak Loads
Prescreening Equipment Generally Required	No Prescreening Equipment Required	No Prescreening Equipment Required
Aeration Required for Both Oxygen & Mixing	Aeration Required only for Oxygen Demand	No Aeration used for Oxygen Demand
Can Have Odor Issues	Odor-Free WWTP	Can Have Odor Problems
Sludge Handling & Regulation Required	Possible Future Sludge Removal Required	Possible Future Sludge Removal Required
High Consumables/Chemicals	Few Consumables/Chemicals	No Consumables/Chemicals
High Level of Operator	Very Low Operator Attention/Expertise	Very Low Operator Attention/Expertise

Activated Sludge	Aerated Lagoons	Waste Stabilization Ponds
High CAPEX	Low CAPEX	Lowest CAPEX
High initial cost and complex, expensive ongoing energy & operations costs	Low initial cost and lower ongoing energy & operations costs	Low initial cost and low ongoing energy & operations costs, but several common problems
Shock & Peak Loads Can Upset Process	Easily Accepts Shock & Peak Loads	Problems With Shock & Peak Loads
Prescreening Equipment Generally Required	No Prescreening Equipment Required	No Prescreening Equipment Required
Aeration Required for Both Oxygen & Mixing	Aeration Required only for Oxygen Demand	No Aeration used for Oxygen Demand
Can Have Odor Issues	Odor-Free WWTP	Can Have Odor Problems
Sludge Handling & Regulation Required	Possible Future Sludge Removal Required	Possible Future Sludge Removal Required
High Consumables/Chemicals	Few Consumables/Chemicals	No Consumables/Chemicals
High Level of Operator	Very Low Operator Attention/Expertise	Very Low Operator Attention/Expertise

Activated Sludge	Aerated Lagoons	Waste Stabilization Ponds
High CAPEX	Low CAPEX	Lowest CAPEX
High initial cost and complex, expensive ongoing energy & operations costs	Low initial cost and lower ongoing energy & operations costs	Low initial cost and low ongoing energy & operations costs, but several common problems
Shock & Peak Loads Can Upset Process	Easily Accepts Shock & Peak Loads	Problems With Shock & Peak Loads
Prescreening Equipment Generally Required	No Prescreening Equipment Required	No Prescreening Equipment Required
Aeration Required for Both Oxygen & Mixing	Aeration Required only for Oxygen Demand	No Aeration used for Oxygen Demand
Can Have Odor Issues	Odor-Free WWTP	Can Have Odor Problems
Sludge Handling & Regulation Required	Possible Future Sludge Removal Required	Possible Future Sludge Removal Required
High Consumables/Chemicals	Few Consumables/Chemicals	No Consumables/Chemicals
High Level of Operator	Very Low Operator Attention/Expertise	Very Low Operator Attention/Expertise

Activated Sludge	Aerated Lagoons	Waste Stabilization Ponds
High CAPEX	Low CAPEX	Lowest CAPEX
High initial cost and complex, expensive ongoing energy & operations costs	Low initial cost and lower ongoing energy & operations costs	Low initial cost and low ongoing energy & operations costs, but several common problems
Shock & Peak Loads Can Upset Process	Easily Accepts Shock & Peak Loads	Problems With Shock & Peak Loads
Prescreening Equipment Generally Required	No Prescreening Equipment Required	No Prescreening Equipment Required
Aeration Required for Both Oxygen & Mixing	Aeration Required only for Oxygen Demand	No Aeration used for Oxygen Demand
Can Have Odor Issues	Odor-Free WWTP	Can Have Odor Problems
Sludge Handling & Regulation Required	Possible Future Sludge Removal Required	Possible Future Sludge Removal Required
High Consumables/Chemicals	Few Consumables/Chemicals	No Consumables/Chemicals
High Level of Operator	Very Low Operator Attention/Expertise	Very Low Operator Attention/Expertise

An example of comparison:

Treatment Technologies	Required BOD	Available Area	Water Quality Effluent	Area	Cost	Evaluation
Conventional Activated Sludge			BOD <20	10	100	
Aerated Lagoon	100	50	BOD<50	20	50	
Stabilization Pond			50<BOD<70	30	30	Selected

Kindly choose the most suitable method for treatment of wastewater. As the total area available is 100 hectors and required effluent quality of BOD should be less than 80mg/l?

Treatment Technologies	Required BOD	Available Area	Water Quality Effluent	Area	Cost	Evaluation
Conventional Activated Sludge			BOD <40	20	100	
Aerated Lagoon	80	100	BOD<60	75	50	
Stabilization Pond			BOD<80	95	30	

Kindly choose the most suitable method for treatment of wastewater. As the total area available is 50 hectors and required effluent quality of BOD should be less than 80mg/l?

Treatment Technologies	Required BOD	Available Area	Water Quality Effluent	Area	Cost	Evaluation
Conventional Activated Sludge	80	50	BOD <20	20	100	
Aerated Lagoon			BOD<60	75	50	
Stabilization Pond			BOD<80	95	30	

Kindly choose the most suitable method for treatment of wastewater. As the total area available is 20 hectors and required effluent quality of BOD should be less than 80mg/l?

Treatment Technologies	Required BOD	Available Area	Water Quality Effluent	Area	Cost	Evaluation
Conventional Activated Sludge	80	20	BOD <40	20	100	
Aerated Lagoon			BOD<60	75	50	
Stabilization Pond			BOD<80	95	30	

Kindly choose the most suitable method for treatment of wastewater. As the total area available is 80 hectors and required effluent quality of BOD should be less than 80mg/l?

Treatment Technologies	Required BOD	Available Area	Water Quality Effluent	Area	Cost	Evaluation
Conventional Activated Sludge	80	80	BOD <40	20	100	
Aerated Lagoon			BOD<60	75	50	
Stabilization Pond			BOD<80	95	30	

Kindly choose the most suitable method for treatment of wastewater. As the total area available is 80 hectors and required effluent quality of BOD should be less than 50mg/l?

Treatment Technologies	Required BOD	Available Area	Water Quality Effluent	Area	Cost	Evaluation
Conventional Activated Sludge	50	80	BOD <40	20	100	
Aerated Lagoon			BOD<60	75	50	
Stabilization Pond			BOD<80	95	30	

Kindly choose the most suitable method for treatment of wastewater. As the total area available is 80 hectors and required effluent quality of BOD should be less than 25mg/l?

Treatment Technologies	Required BOD	Available Area	Water Quality Effluent	Area	Cost	Evaluation
Conventional Activated Sludge	25	80	BOD <40	20	100	
Aerated Lagoon			BOD<60	75	50	
Stabilization Pond			BOD<80	95	30	

Kindly choose the most suitable method for treatment of wastewater. As the total area available is 100 hectors and required effluent quality of BOD should be less than 70mg/l?

Treatment Technologies	Required BOD	Available Area	Water Quality Effluent	Area	Cost	Evaluation
Conventional Activated Sludge	70	100	BOD <40	20	100	
Aerated Lagoon			BOD<60	75	50	
Stabilization Pond			BOD<80	95	30	

Kindly choose the most suitable method for treatment of wastewater. BOD of influent is 250mg/l. As the total area available is 80 hectors and required effluent quality of BOD should be less than 70mg/l?

Treatment Technologies	Required BOD	Available Area	Removal rate of BOD	Area	Cost	Evaluation
Conventional Activated Sludge	70	80	<90%	20	100	
Aerated Lagoon			<60%	75	50	
Stabilization Pond			<40%	95	45	

Kindly choose the most suitable method for treatment of wastewater. BOD of influent is 200mg/l. As the total area available is 80 hectors and required effluent quality of BOD should be less than 100mg/l?

Treatment Technologies	Required BOD	Available Area	Removal rate of BOD	Area	Cost	Evaluation
Conventional Activated Sludge	100	80	80%	20	100	
Aerated Lagoon			60%	60	50	
Stabilization Pond			50%	75	45	

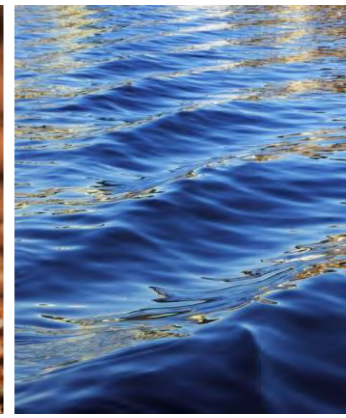
Kindly choose the most suitable method for treatment of wastewater. BOD of influent is 240mg/l. As the total area available is 80 hectors and required effluent quality of BOD should be less than 100mg/l?

Treatment Technologies	Required BOD	Available Area	Removal rate of BOD	Area	Cost	Evaluation
Conventional Activated Sludge	100	80	80%	20	100	
Aerated Lagoon			60%	50	50	
Stabilization Pond			50%	75	45	

Sewerage generation of Lahore City is 200 liters per capita per day. As the papulation of city is 1.25million and 90% of the papulation have sewer facility. Kindly calculate the sewerage generation in m3 per hour?


THANK YOU

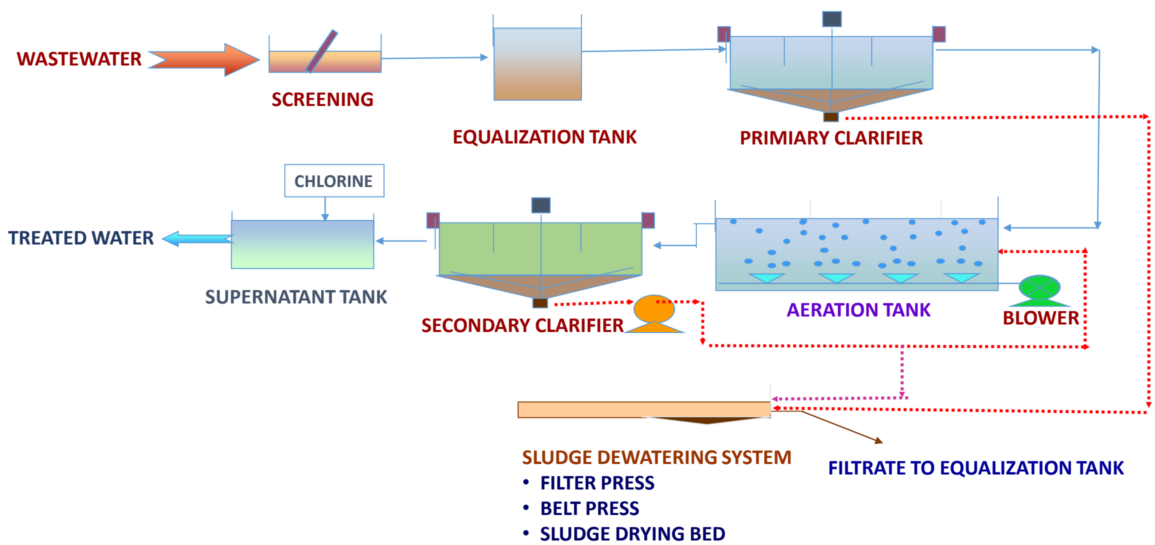
Wastewater Treatment Technologies

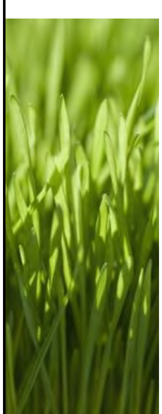


Content:

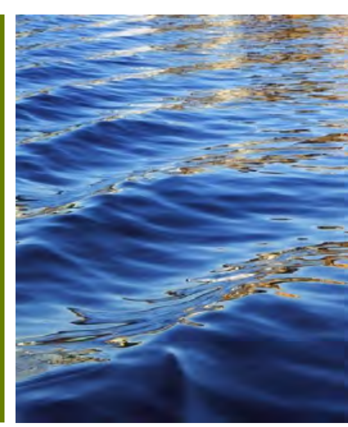
- Introduction to Wastewater Treatment
- Waste Stabilization Ponds
- Activated Sludge Process
- Trickling Filters

Activated Sludge Process





Pre-Treatment



Preliminary Treatment

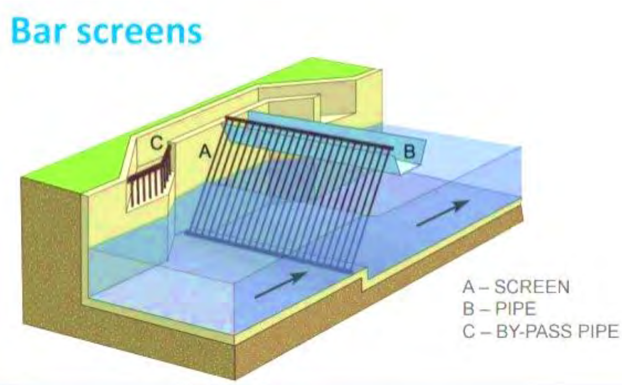
Sewer → Coarse Screens (optional) → Grit Removal (optional) → Fine Screens → Primary Treatment

What comes down the sewer?

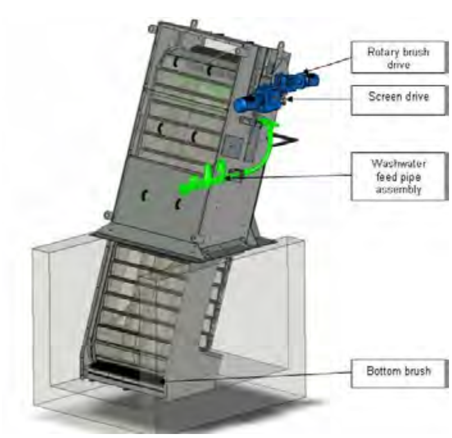
Getting the big stuff out

Coarse Screen

Usually around 25mm bars to take the big stuff out



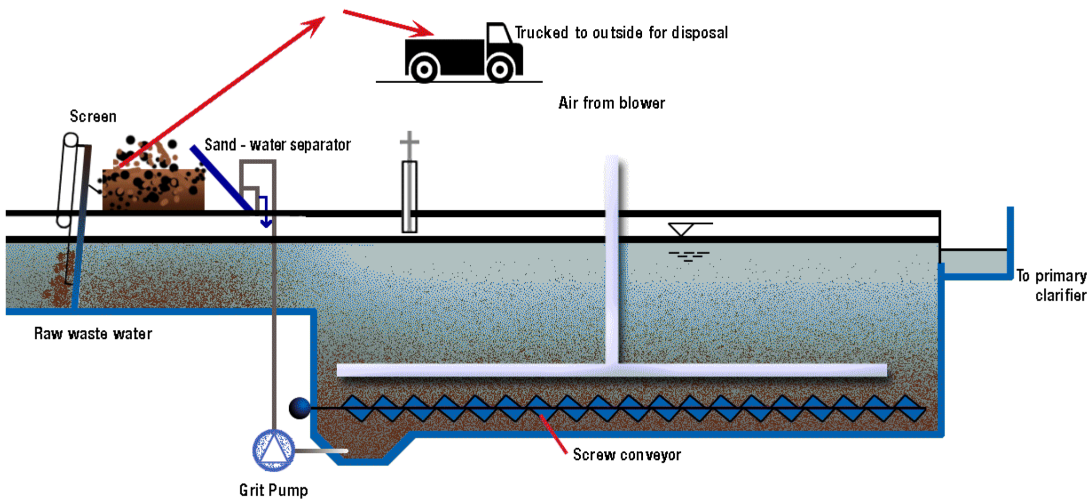
Taking out the fine stuff



Fine screens

Typically a function of the consent and are normally specified as 6mm in 2 dimensions

Grit Removal

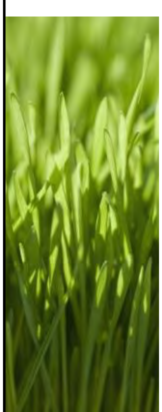


Screen & Aerated Grit Chamber

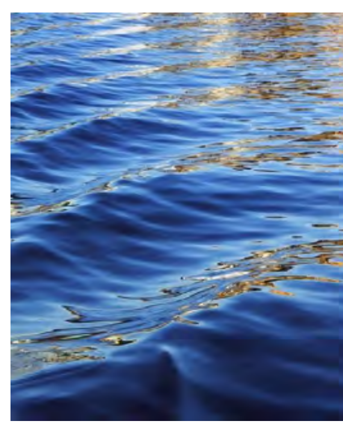
What happens when preliminary treatment goes wrong?

And What goes right

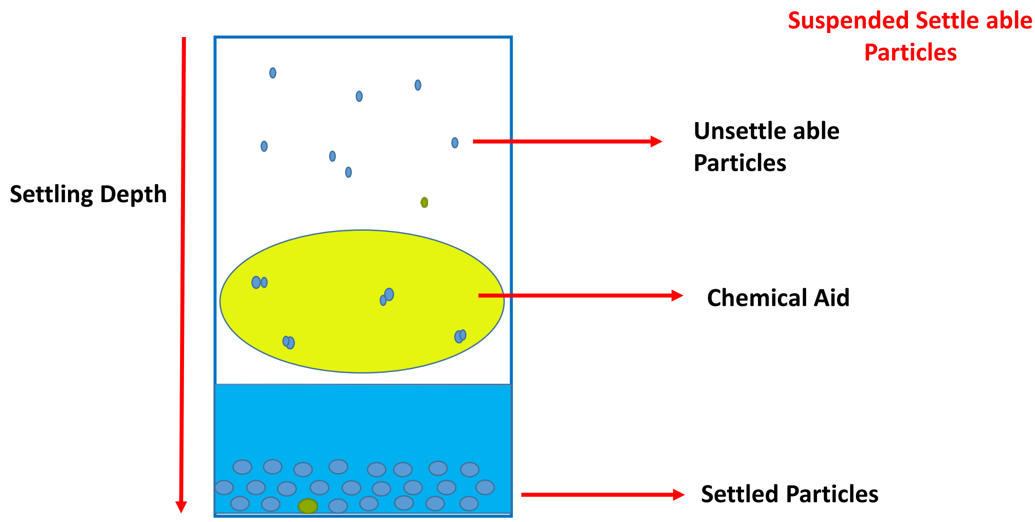
11



Primary Treatment



Science of Primary Treatment

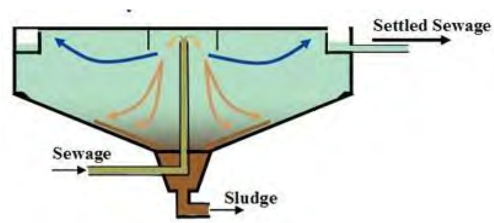


Primary Settlement

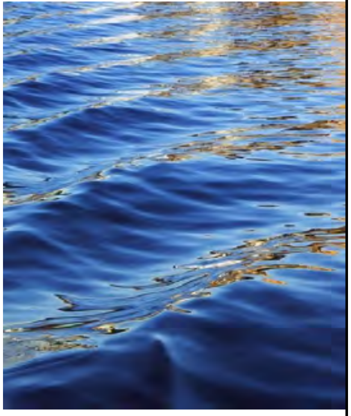
- Rely on gravity to settle out lighter SS material Circular or Rectangular constructions
- Minimum 2 hours retention at peak flow
- 30-40% removal of organic load and 60% of solids
- High calorific value removed and goes off to digesters to produce energy

Primary Settlement

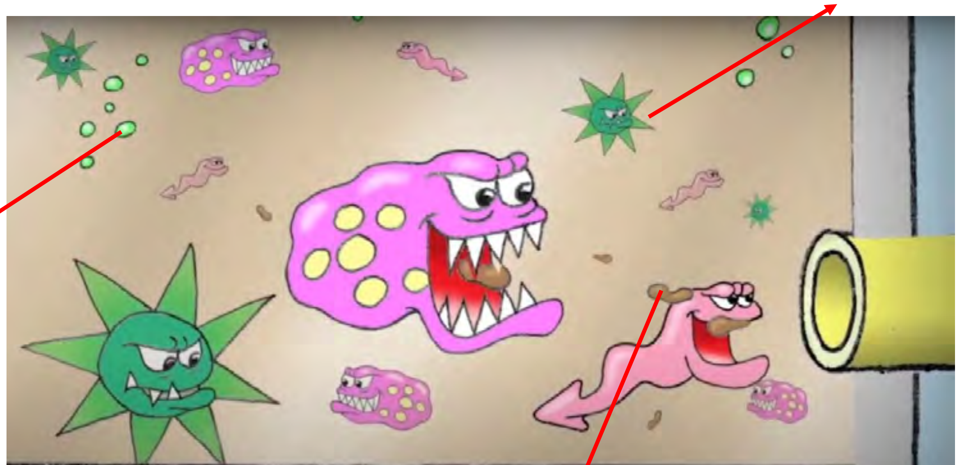
- Fluid retention time of at least 2 hours
- Scraper bridge scrapes it into the Hopper
- Sludge collects in the bottom
- Sludge removed by pump periodically either manually, by timer, solids mode or level control



Secondary Treatment



Science of Secondary Treatment



Secondary Treatment

- Degrade biological content (dissolved organic matter) of the sewage
- Ex: human waste, food waste, soaps, detergent
- Added bacteria and protozoa into sewage
- 3 different approaches
- Activated Sludge Process
- Trickling Filters
- Lagoon system

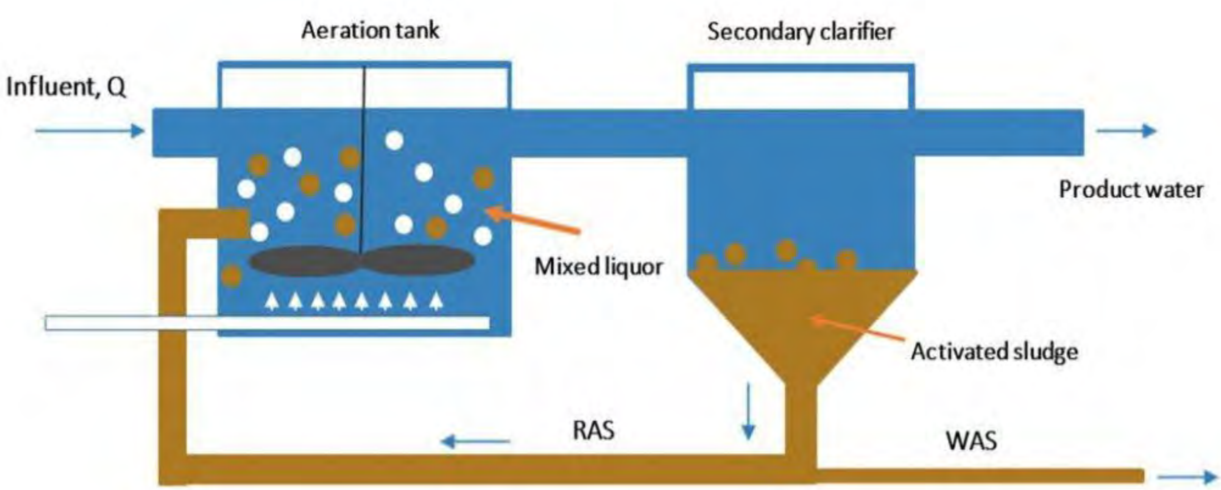
Secondary Treatment

Engine Room of Wastewater Treatment

Primary Treatment → Secondary Treatment → Tertiary Treatment/ Outfall

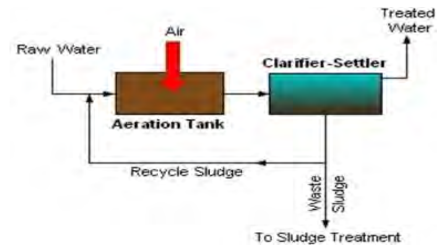
Secondary Treatment ↓ Sludge Treatment

Secondary Treatment



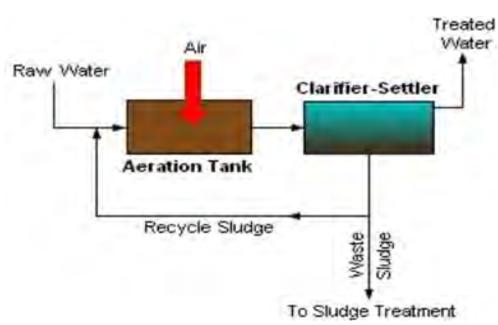
Activated Sludge Process (ASP)

Activated sludge consists of a mass of micro-organisms which feed on pollutants in the sewage. The bacteria is suspended in liquid and is called “mixed liquor”, it is mixed with sewage and aerated in aeration basins before passing to final settlement tanks where it is settled and the sludge returned. The effluent produced is of a high quality.



Activated Sludge Process (ASP)

- Sewage enters the aeration tank and mixes with mixed liquor
- Bacteria eat the sewage and need to be fed with air
- More bacteria are bred and old sludge needs to be wasted to maintain a balance
- Sludge recycled around to ensure the mass of bacteria is maintained.



Activated Sludge Process (ASP)

5 Component of Activated Sludge Process

- Aeration Tank
- Aeration Source
- Secondary Clarifiers
- Activated sludge outflow line (RAS and WAS)
- Effluent outflow line

5 Component of Activated Sludge Process

Aeration Tank

Oxygen is introduced into the system

Activated Sludge Process

Aeration Source

Ensure that adequate oxygen
is fed into the tank provided pure
oxygen or compressed air

Activated Sludge Process

Secondary Clarifiers

Activated-sludge solids separate from the surrounding wastewater

Activated Sludge Process

Activated sludge outflow line

Pump activated sludge back to the aeration tank

Effluent outflow line

discharged effluent into bay or tertiary treatment plant

Activated Sludge Process (ASP)

Advantages
- Very efficient producing a high quality effluent
- Common technique with a lot of industry knowledge
- Very adaptable to increasing loads
- Can be adapted for Nutrient Removal

Disadvantages
- Energy intensive
- More complicated to operate than fixed film processes
- Produces more sludge than fixed film

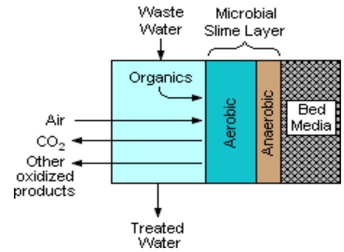
Samples for different treatment units

Trickling Filters

- Fixed film process meaning the bacteria grows on the rocks and settled sewage is applied to it

- Settled sewage is dosed onto the filters using mechanical distributors.

- Parts of the slime regularly break away from the media surface and final settlement in humus tanks is required to produce a high quality final effluent.



Trickling Filters

Filter Media

- The filter media provides a surface for the biomass to grow upon and is generally made of slag, stone or plastic.
- The biomass requires air to survive and this is achieved through natural ventilation within the filter. This relies on fresh air having a direct path to the base of the filter which is achieved through vent pipes, holes or open center wells. It is important that these are kept clear.

Recirculation

- To maintain good wetting of filters most sites recirculate a flow of final effluent. This improves performance by a mixture of dilution and better distribution of flow throughout the filter

Trickling Filters

Advantages

- Simple and easy to operate
- Low or no power
- Relatively cheap to build
- Resilient and robust to change and toxic shock
- Adaptable

Disadvantages

- Large land take
- Not as efficient a removal process as suspended growth
- Not resistant to the cold
- Overgrowth and clogging

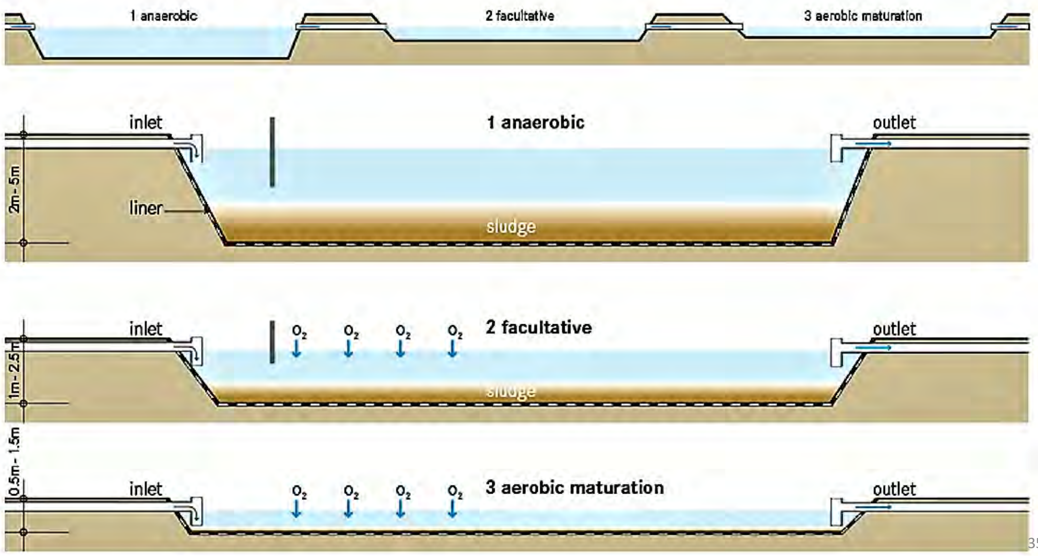
Lagoon Systems

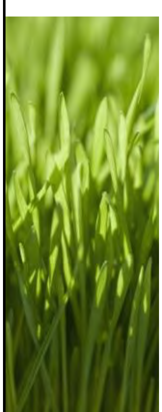
Hold the waste-water for several days to months

Natural degradation of sewage

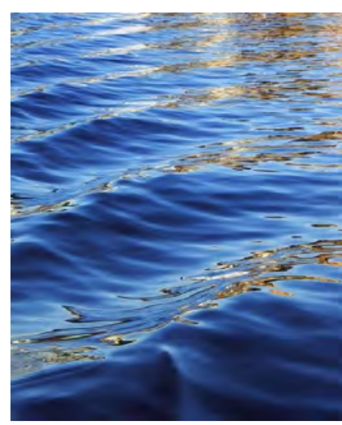
Usually Phyto-remediation is preferred

Stabilization Ponds / Lagoons

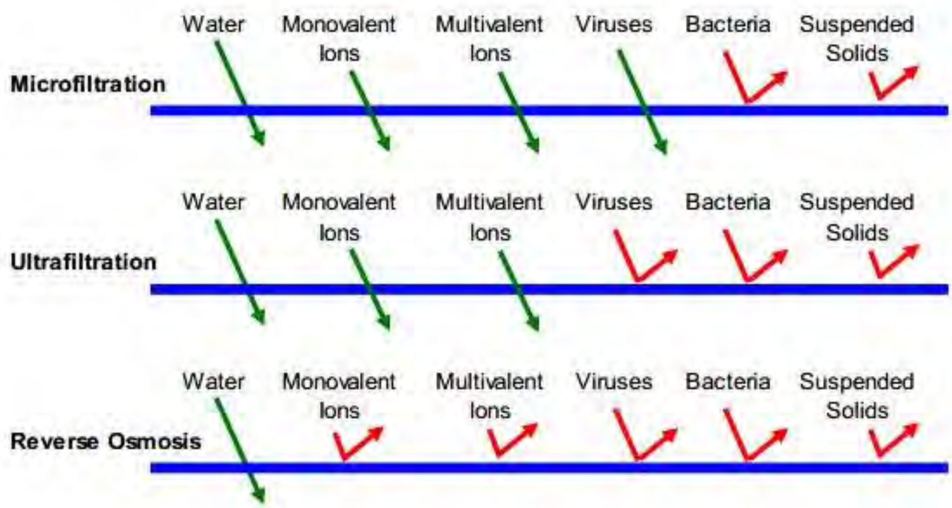




Tertiary Treatment



Membranes Separation



UV Light Radiation

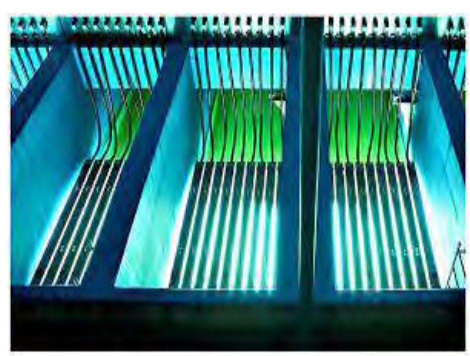
- Damage the genetic structure of bacteria, viruses and other pathogens.

Advantages

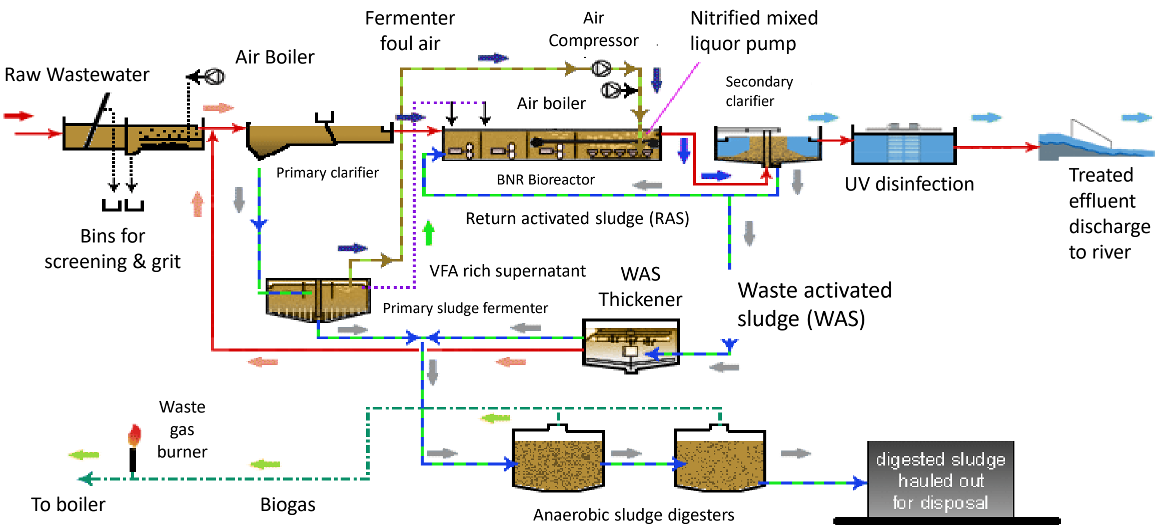
- No chemicals are used
- No harmful byproducts

Disadvantages

- High maintenance of the UV- lamp



FLOW DIAGRA



Raw Wastewater
Air Boiler
Fermenter foul air
Air Compressor
Nitrified mixed liquor pump
Secondary clarifier
Air boiler
Primary clarifier
BNR Bioreactor
UV disinfection
Treated effluent discharge to river
Bins for screening & grit
Return activated sludge (RAS)
VFA rich supernatant
WAS Thickener
Waste activated sludge (WAS)
Primary sludge fermenter
Waste gas burner
To boiler
Biogas
Anaerobic sludge digesters
digested sludge hauled out for disposal

Annex 5.1.47 Training Material for "O&M of Mechanical and Electrical Equipment" in Summer 2022

O&M of Electrical & Mechanical System

Pump, Motors, Motor Control units and Valves

By
Jawad Shahid
Vice Principal

Importance of Tube Well Pumps

This could be my home !

Importance of Disposal Station Pumps

This could be our children !

Topics to cover..

- ✓ Types of Pumps
- ✓ Pump operations
- ✓ Preventive maintenance of pumps
- ✓ Induction Motors
- ✓ Motor Control Units
- ✓ Valves and their Operation
- ✓ Asset Lifecycle Assessment
- ✓ Vibration Analysis
- ✓ Pump series and parallel op.
- ✓ Motor Starters,Pump Performance curve
- ✓ Preparation of Operational Plan
- ✓ Introduction to E-Learning Platform

Icebreaker and Class Introduction

Now it is your turn…

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

  WASA equipment?

Brainstorming

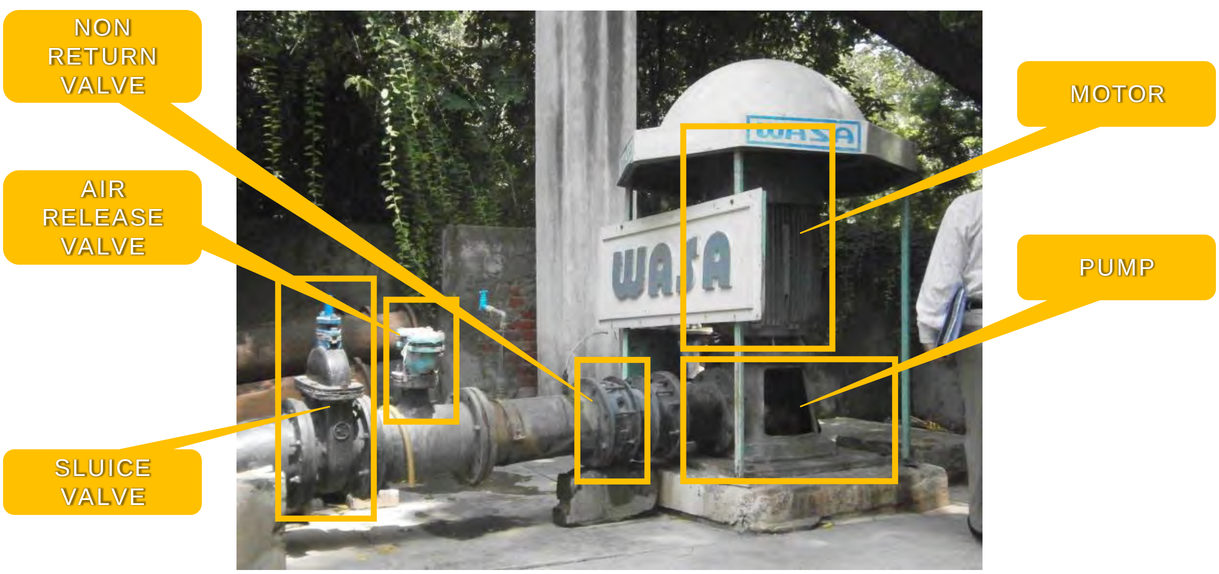
Now it is your turn…

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

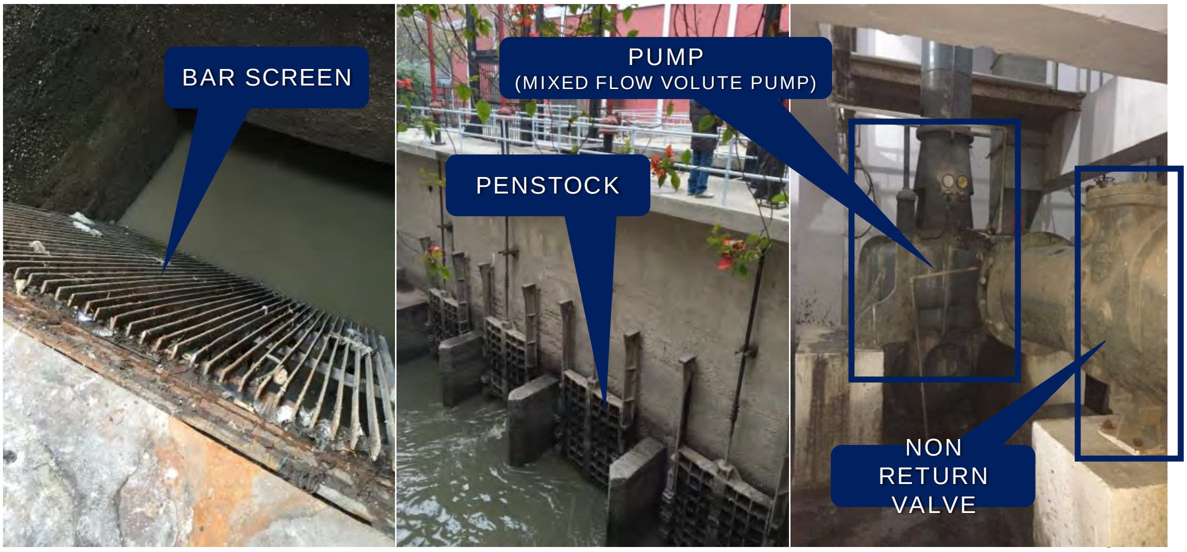
Resources and Handouts

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

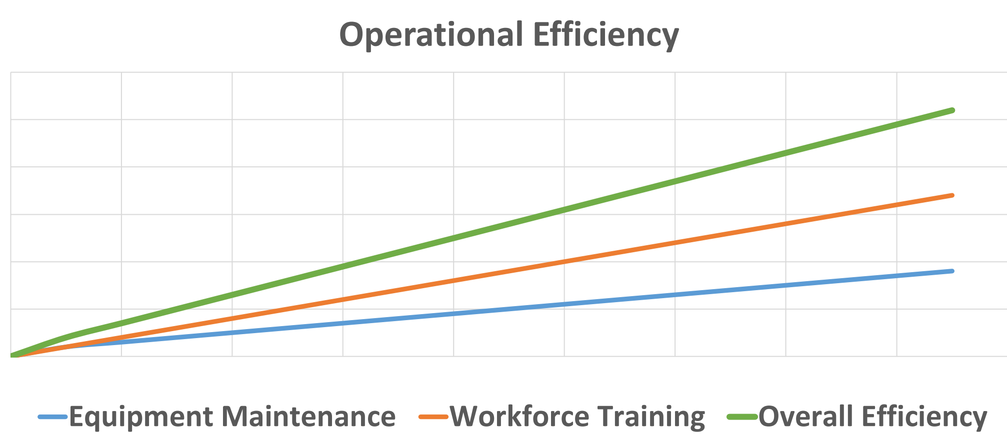
Introduction to Pumps (Tube Well)



Introduction to Pumps (Disposal Station)



Importance of Equipment Reliability and Trainings

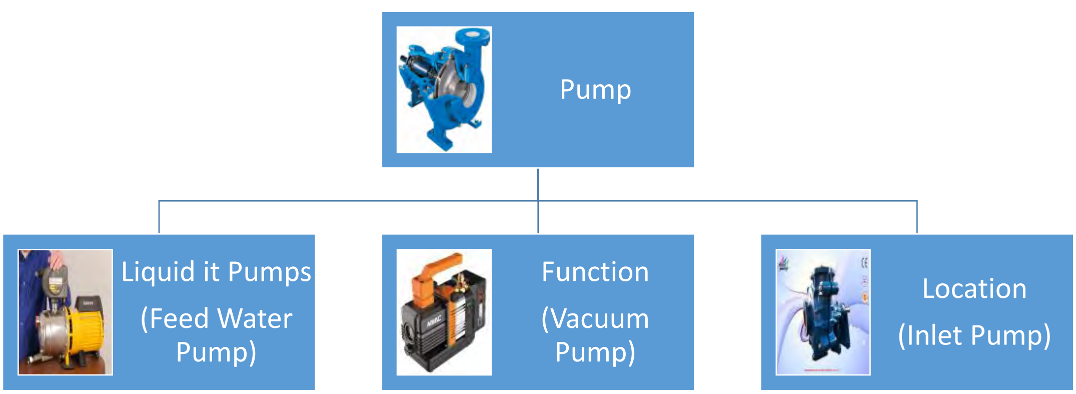


Introduction to Pumps

Pump

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

Identification of Pumps



Introduction to Pumps

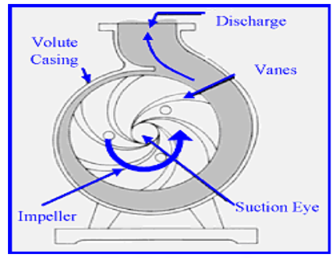
Two major categories:

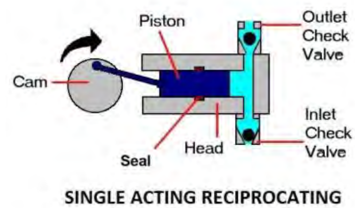
i) Centrifugal Pumps

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

ii) Positive Displacement Pumps

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

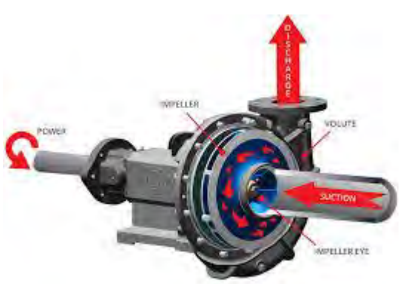




Introduction to Pumps

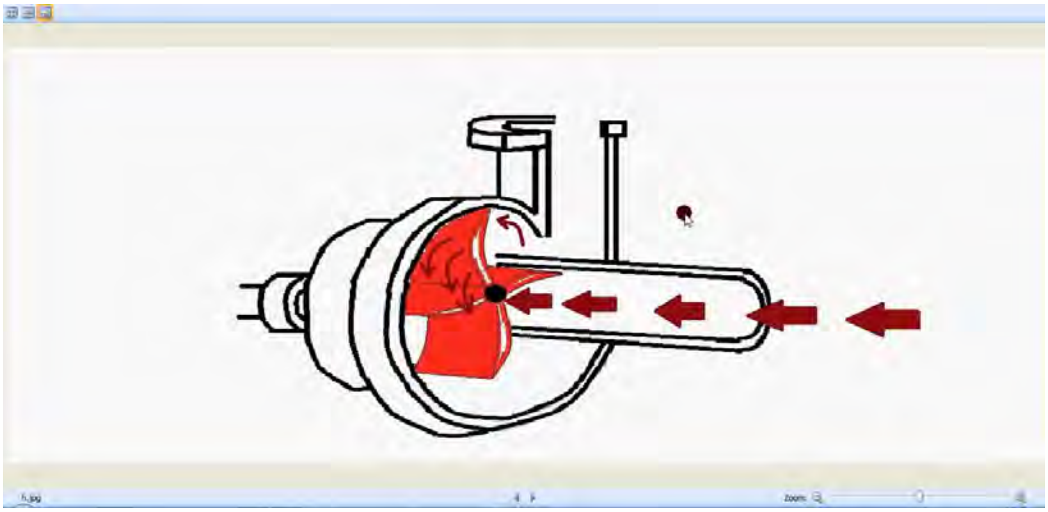
Centrifugal Pumps

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



Centrifugal Pump

Video Centrifugal Pumps



Introduction to Pumps

General Design and Parameters…

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

✓**Short lifecycle**

✓**Operational downtime**

✓**Energy loss**

✓**Major capital loss**

Selection Criteria of Pumps

How to select a pump?

How much water is needed?

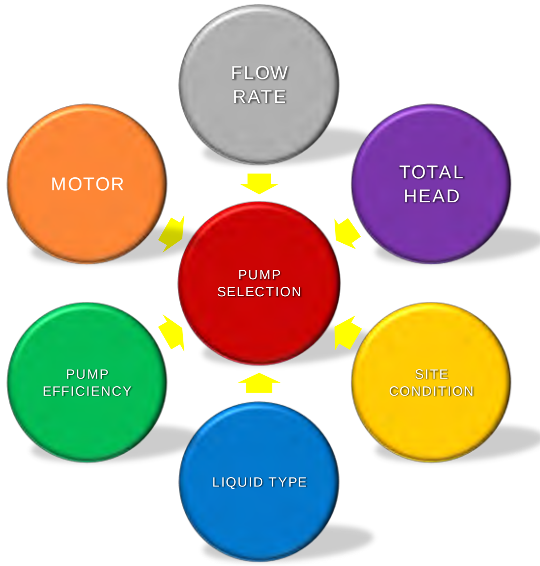
How far or high water will be delivered?

Is there a guaranteed pump efficiency need?

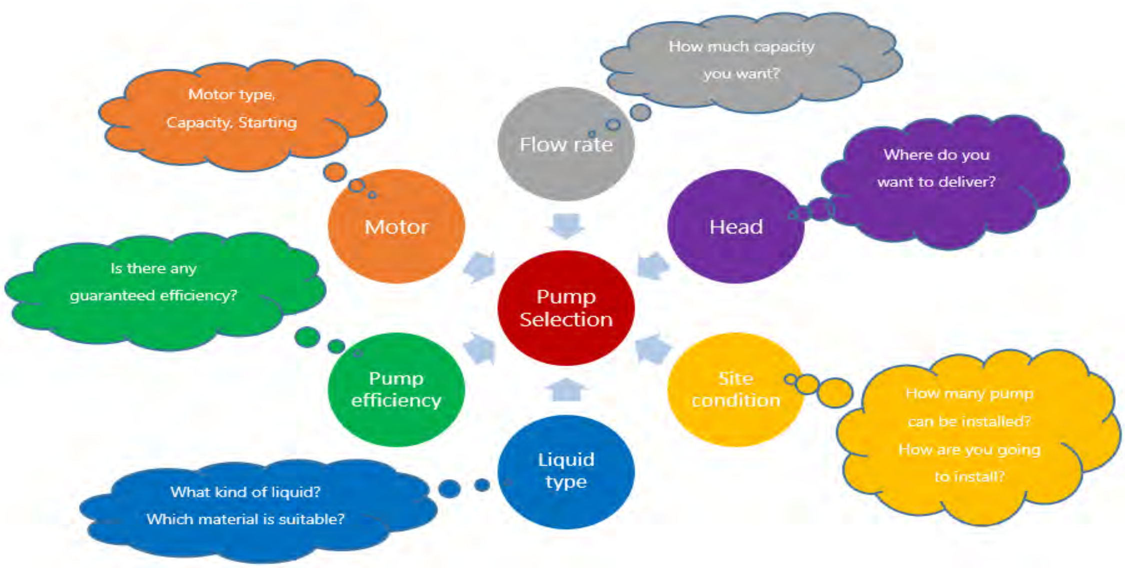
What kind of liquid is transported?

How much space is available for pump installation?

Motor/energy factor?



Selection Criteria of Pumps



Selection Criteria of Pumps

Parameters

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

Selection Criteria for Pumps

Other Parameters

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

Introduction to Pump Design Basics

Centrifugal Pump Nameplate and Designation

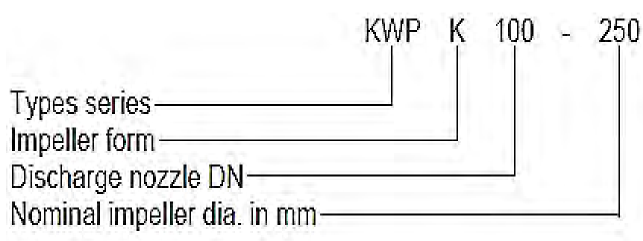
Specification:

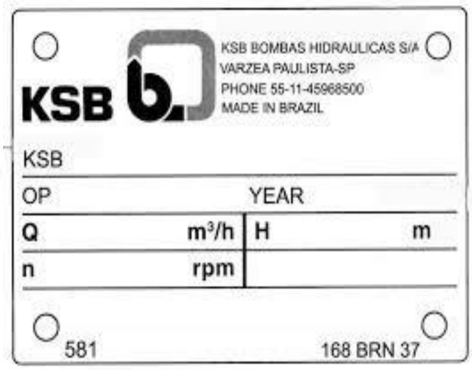
Discharge Diameter: 40--500mm(1.6--20inch)

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

Head: 6--80m

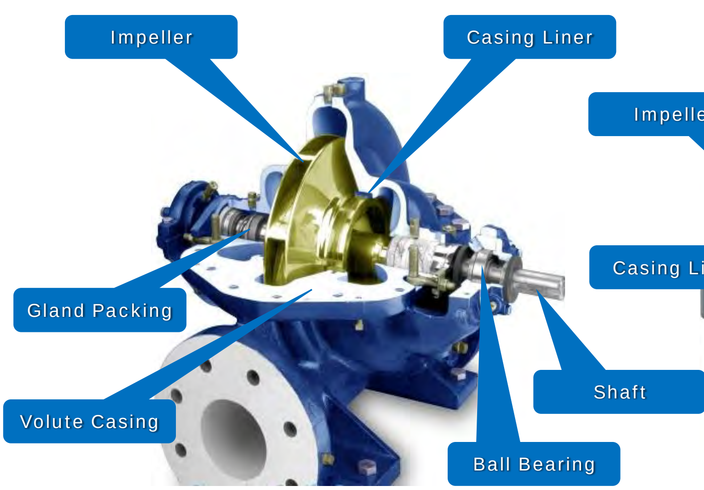
Name Plate and Designation



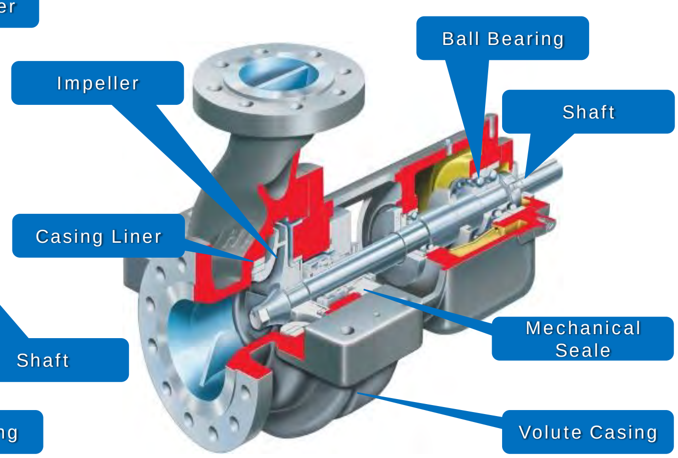


Assembly Parts of Pumps

Centrifugal Pump Structural Parts for Disposal Station



Double Suction Volute Pump



Single Suction Volute Pump

Assembly Parts of Pumps

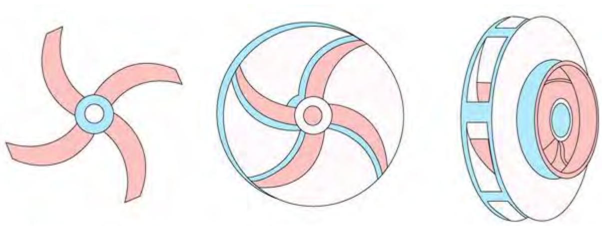
Submersible Pump Structural Parts for Disposal Station

Types of Impellers

Open Impeller
(Curved Blades)

Semi Closed

Closed Impeller
(Curved Blades)



OPEN IMPELLER SEMI IMPELLER ENCLOSED IMPELLER

Introduction to Pumps

Vertical Turbine Pump

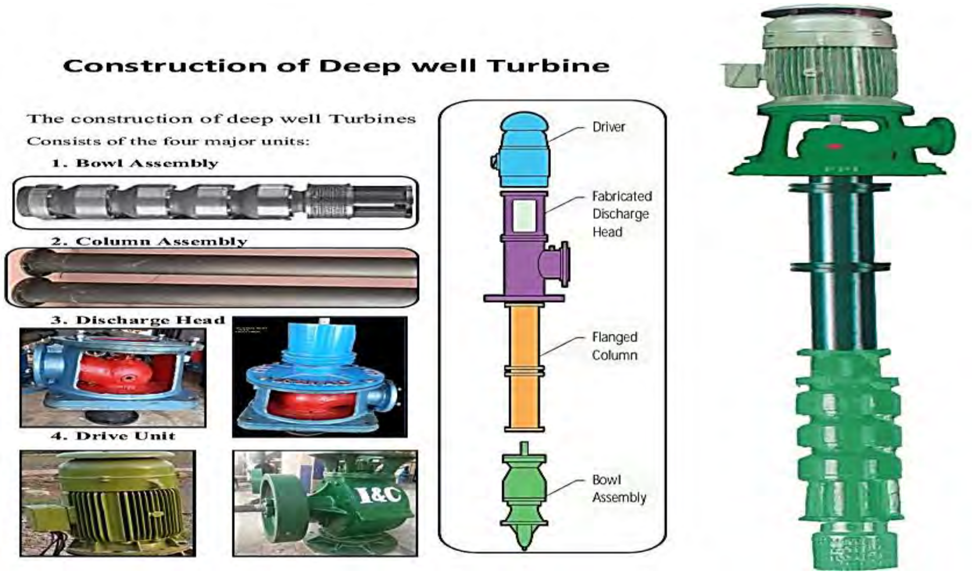
These pumps are commonly used in groundwater wells. These pumps are driven by a shaft rotated by a motor on the surface

Introduction to Pumps Types

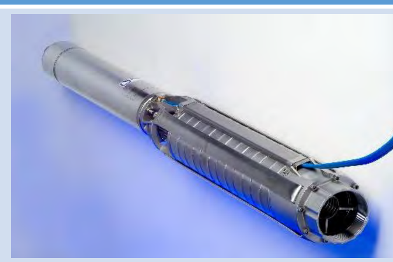
Submersible Pump

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

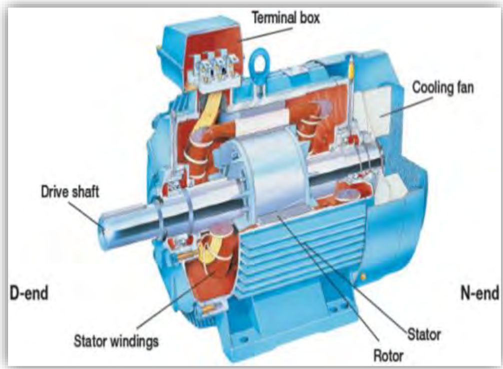


Comparison of Vertical pump and Submersible pump

	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

Introduction to 3 phase Induction Motors

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

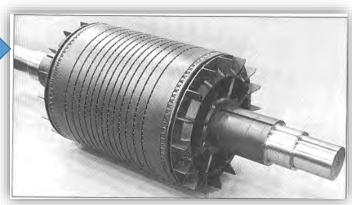


Basic Design and Construction

An induction motor has two main components:

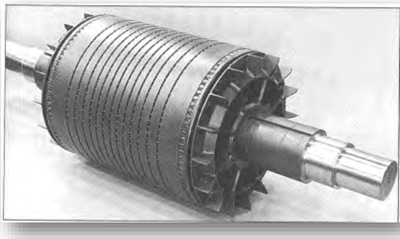
1. (Stationary part) Stator

2. (Revolving part) Rotor



Basic Design and Construction

Rotor Types

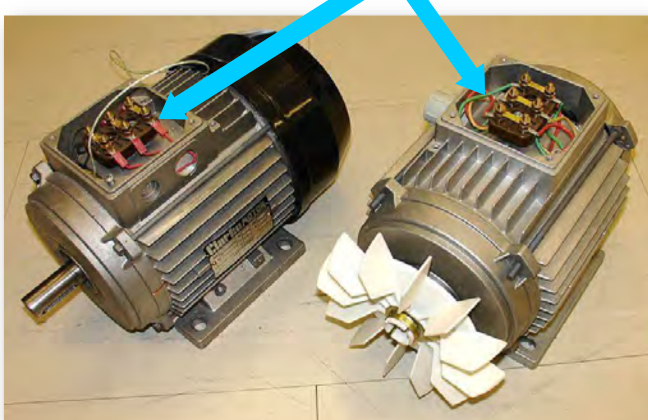


Squirrel cage rotor

Slip ring rotor

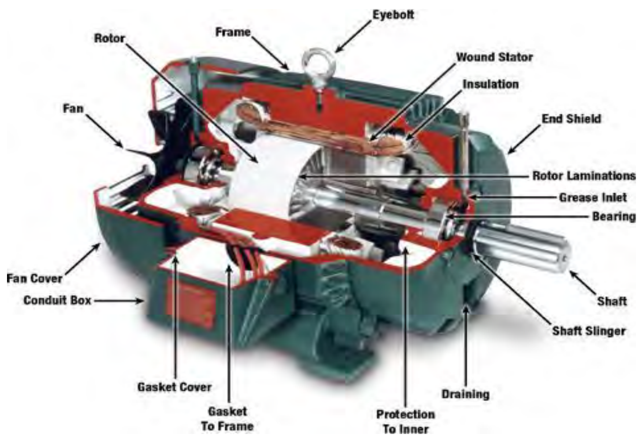
Basic Design and Construction

Terminals



Basic Design and Construction

Section View



Basic Design and Construction

Motor Burnout and Rewinding

Causes…

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

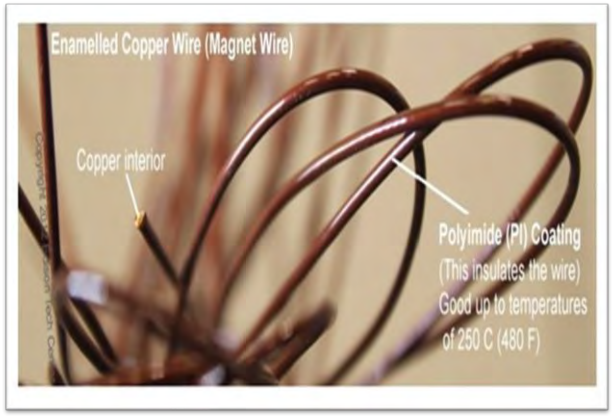
- Poor energy quality
- Load shedding
- Poor water quality
- High number of remedial maintenance operations
- Significant drop in static levels

Motor Burnout and Rewinding

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

Motor Burnout and Rewinding

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



Introduction to Panel Components

What are these?

Components of Electrical Control Panel

~ Motor Control Unit (Outer View) ~

Digital Voltmeter

Locks

Name Plate

Digital Ammeter

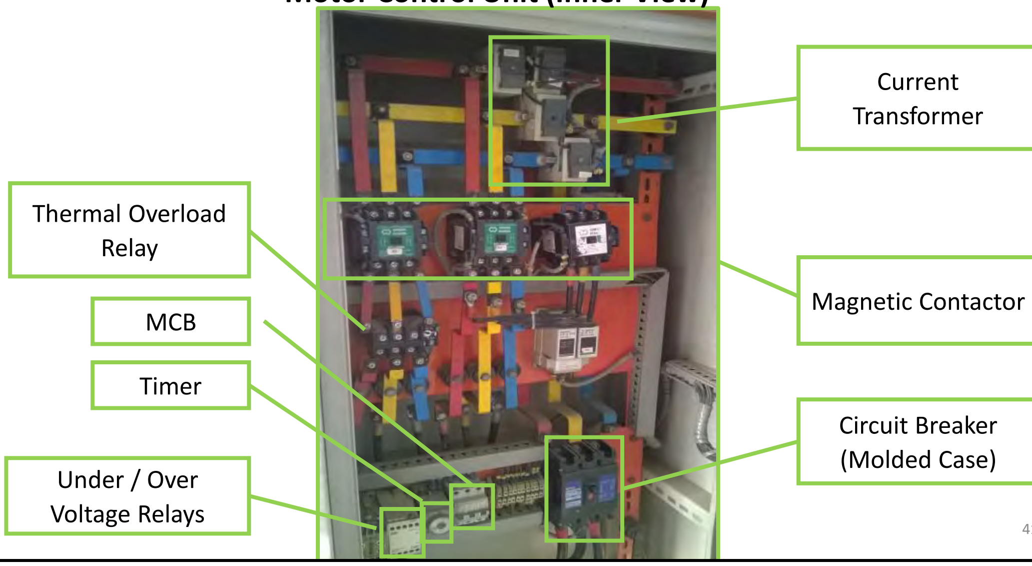
Selector Switch

Alarm/ Indication Lamps

On-Off and Emergence Push Buttons

Components of Electrical Control Panel

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



Selector Switches

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

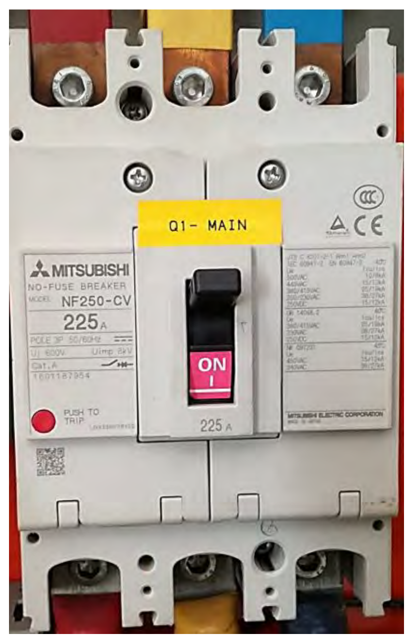
Ampere & Voltmeter meter

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

Zero Adjustment

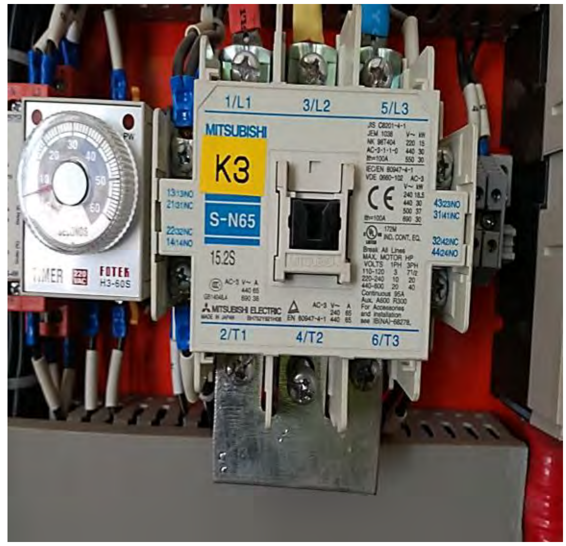
1. Circuit Breakers

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



2. Contactor

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



Protective Relays

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

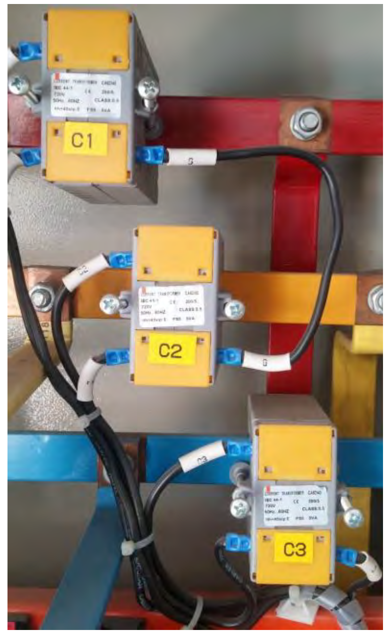
Thermal Relay

Under/Over Voltage Relay

Phase Failure Relay

5. Current transformers (CT)

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



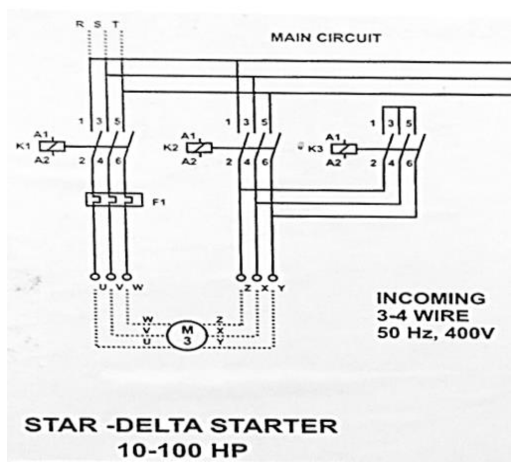
6. Timer

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

WIRING DIAGRAMS

Wiring Diagram

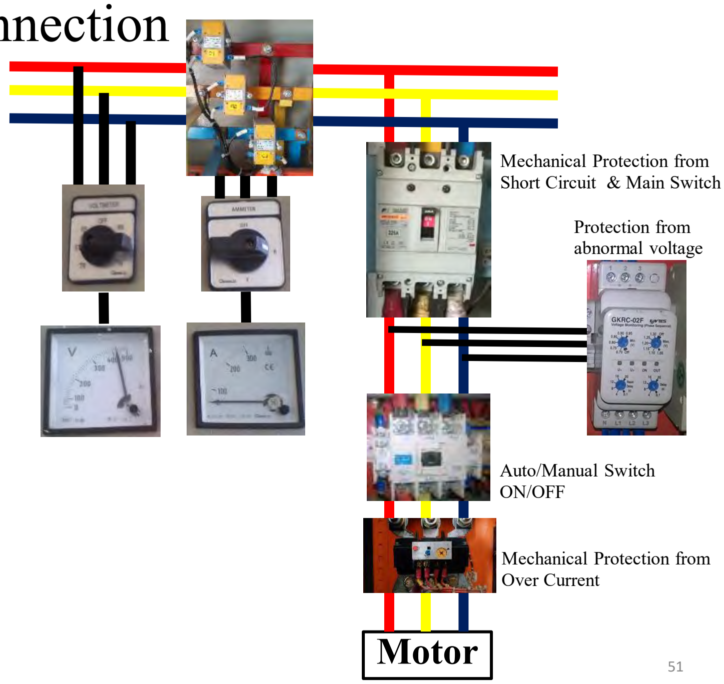
- ✓ Shows how the components are connected
- ✓ It should be always available at the site



Basic Concept of Connection

WAPDA

3 phase, 400V



Basic Power Circuit for Motor

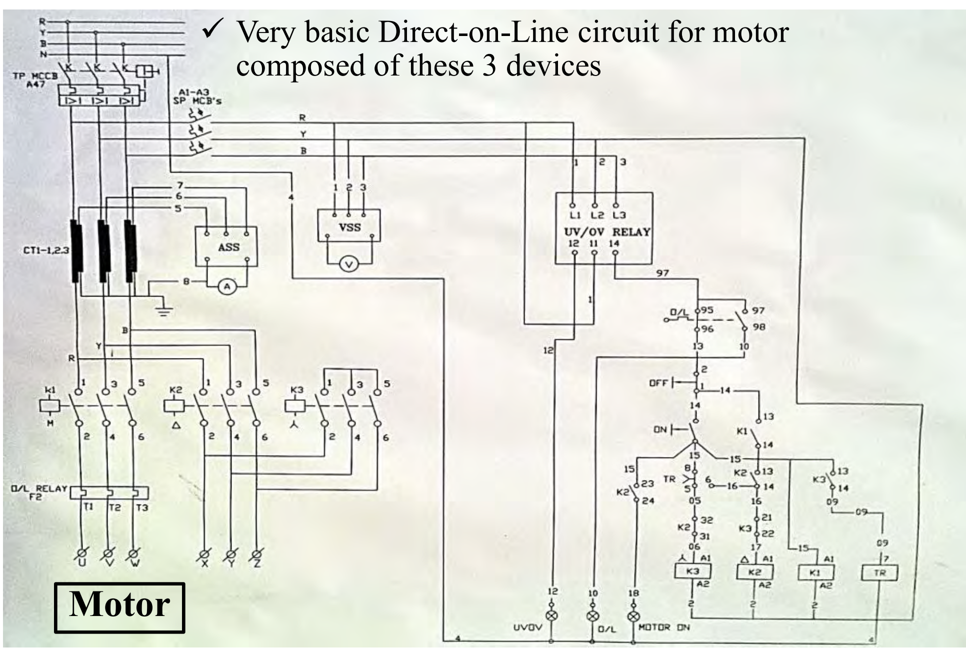
- Circuit Breaker
- Magnetic Contactor
- Over Load/Thermal Relay
- Over/Under Voltage Relay

Monitoring Device

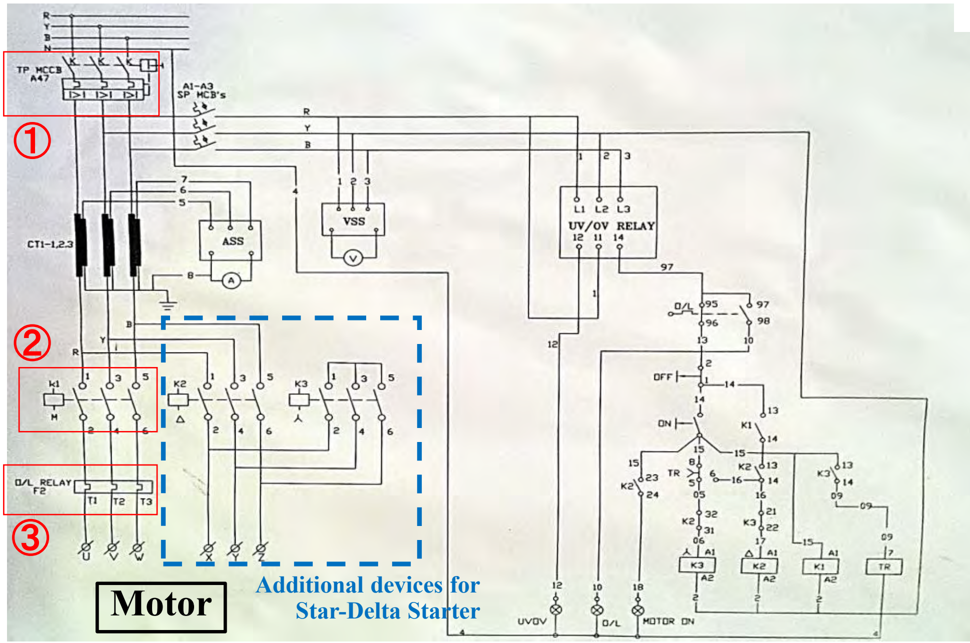
- Voltage Meter
- Ampere Meter

Main Power Circuit

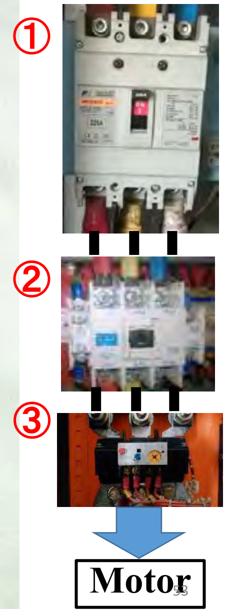
✓ Very basic Direct-on-Line circuit for motor composed of these 3 devices



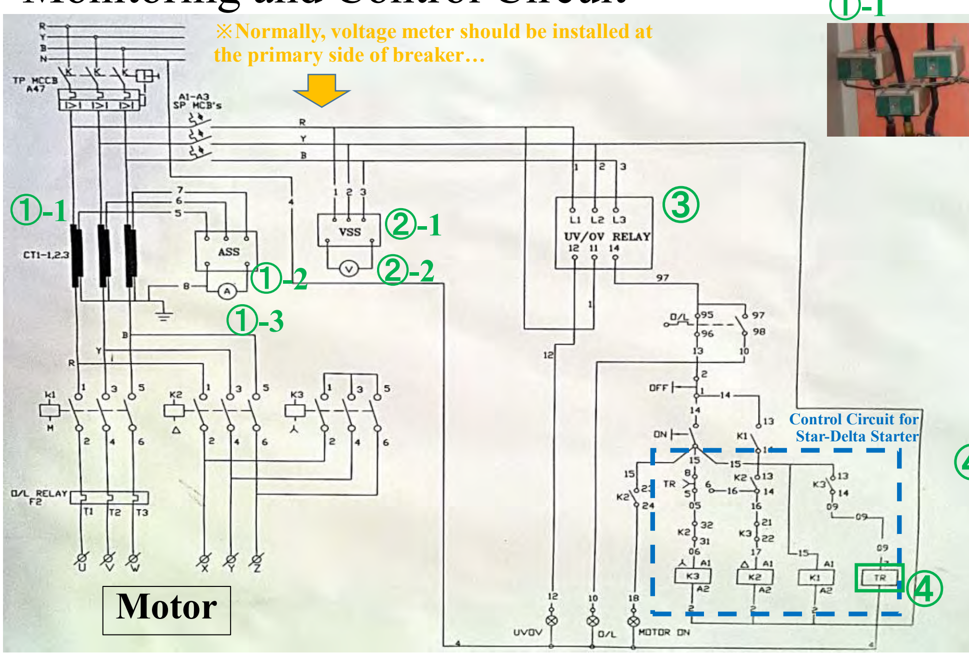
Main Power Circuit

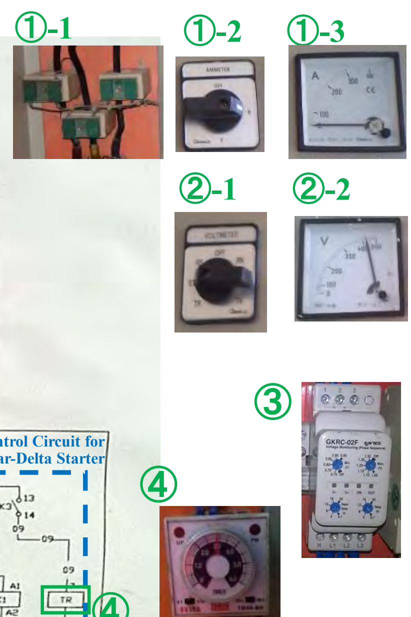


Basic Power Circuit for Motor



Monitoring and Control Circuit





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 process pressure.
- ✓ Relieving component or piping pressure.

Introduction and selection of valves

Classification of Valves

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

Linear Motion Valves.

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

Introduction and selection of valves

Classification of Valves

Rotary Motion Valves.

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

Quarter Turn Valves.

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

Introduction and selection of valves

Classification of valves based on motion

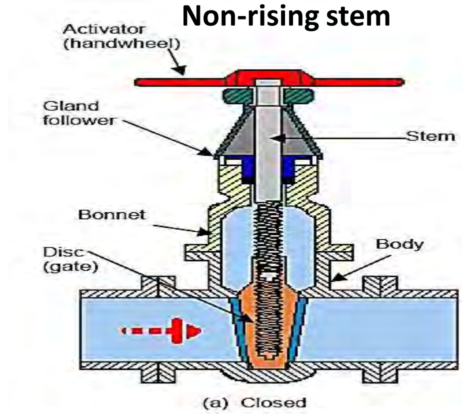
Valve types	Linear motion	Rotary motion	Quarter turn
Gate Valve	x		
Air release valve	x		
Butterfly valve		x	x
Non-return valve		x	x
Flap valve		x	

Assembly parts of valves

Basic Parts of the valve

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

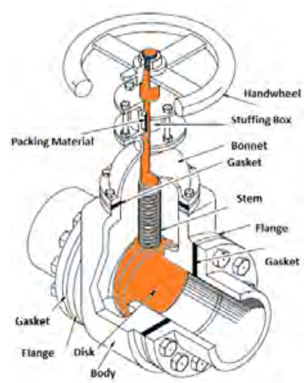
Non-rising stem



Introduction and selection of valves

Methods of controlling flow through a valve.

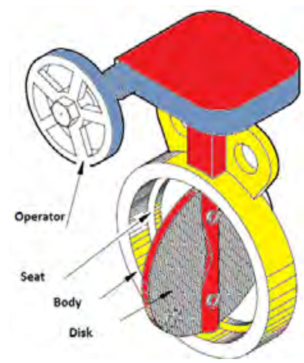
1. Slide a flat, cylindrical, or spherical surface across the orifice.



Gate valve

Introduction and selection of valves

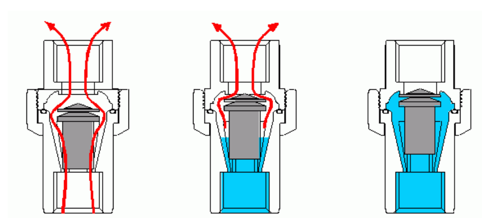
2. Rotate a disc or ellipse about a shaft extending across the diameter of an orifice.



Butterfly valve

Introduction and selection of valves

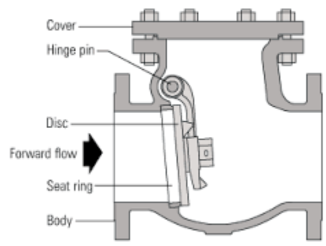
3. Ball linearly moves upwards to close of an orifice.



Air release valve

Introduction and selection of valves

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

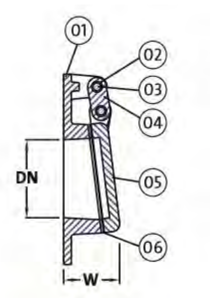


Non return valve

Introduction and selection of valves

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

Insulation Testing for 3-Phase Motor

What is “Insulation Resistance” ?

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

Insulation Resistance Tester

Analysis and Testing Equipment

Step By Step Procedure for Insulation Testing

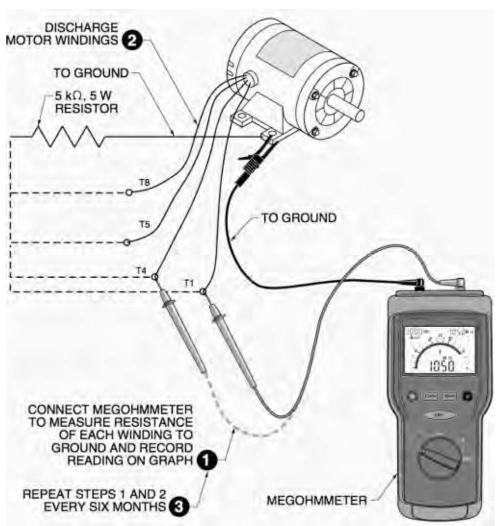
1. Connect the terminals of insulation tester black with earth and red with U_1, V_1 and W_1 one by one with energize insulation tester and note values.
2. Cross winding insulation test

   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.



Sample Format for Preventive Maintenance

Preventive Maintenance Sheet for Electrical Facility

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

① Test in OFF Condition

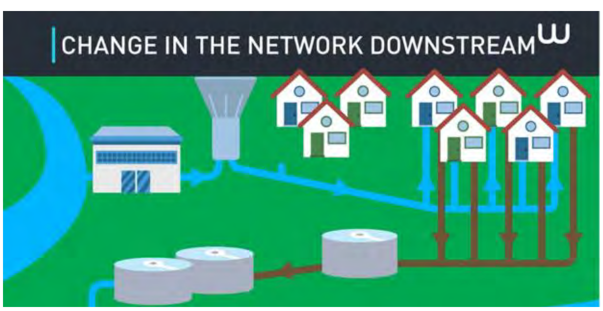
② Test in Running Condition

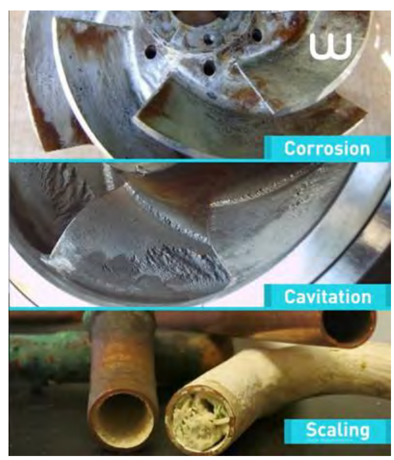
Voltage by Clamp Meter (V)	RY					
	YB					
	BR					
Ampere by Clamp Meter (A)	R					
	Y					
	B					
Power Factor						
Vibration	Upper Bearing	Lower Bearing				
Revolution Per Minute (RPM)						
Temperature	Upper Bearing	Lower Bearing				
	Shaft					
Reference for Insulation Resistance Value:			Good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

Issues in Pumps

Trouble shooting Pumps

1. Corrosion
2. Cavitation
3. Change in Flow and Pressure





Issues in Pumps

Trouble shooting Pumps

1. Corrosion
2. Cavitation
3. Change in Flow and Pressure

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).

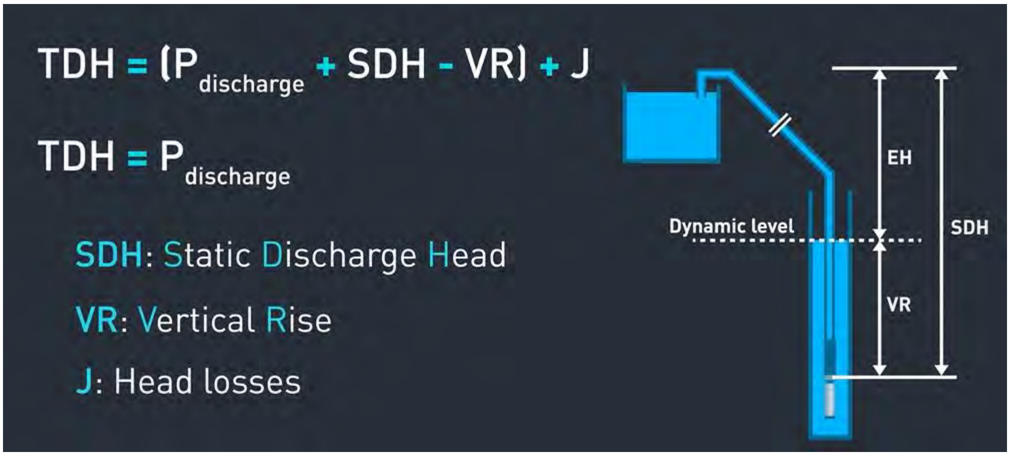
Troubleshooting

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).

Imersed Tubewell Pump

Total Dynamic head



Thank you

Engr. Jawad Shahid

ELECTRICITY to WATER

Introduction to Advanced Energy Audit in Water Supply

By
Jawad Shahid
Vice Principal

Importance of Tube Well Pumps

This could be my home !

Topics to cover..

- Introduction and Importance of Advanced Energy Audit
- Hands on Activity, wiring of MCU
- Energy Audit of miniature Pumping Station
- Use of Electro-Mechanical Equipment
- Data Extraction from Power Analyzer and Ultra-Sonic Flow Meter

Topics to cover..

- Energy Assessment Tool
- Actual Issues faced by WASAs Durin Energy Audit
- Explanation of Q-H curve
- Series and Parallel Pump Operation
- Preparation of Energy Development Plan

Icebreaker and Class Introduction

Now it is your turn…

- Degree and backgrounds?
- Share your work experience relati

WASA equipment?

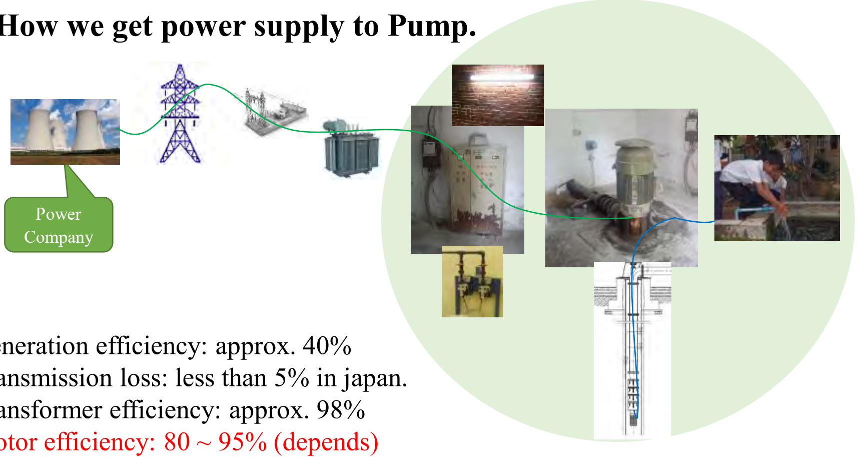
Brainstorming

Now it is your turn…

- Any prior experience of Energy?
- Why interested in this Energy Audit ?
- What best skills do you bring to the class?

ELECTRICITY to WATER

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



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

WHAT IS ENERGY AUDIT ACTIVITY

ELECTRICITY to WATER

Energy Audit: An Energy Audit is an assessment and analysis of Energy Flows in a process, aimed at reducing the amount of energy input into the system without negatively affecting the outputs.

Objective Audit: The main objective of an energy audit is to explore various possibilities for energy conversation.

Approach: An Energy Audit requires a through and detailed study of a system, through the performance of various tests and measurements.

BASIC KNOWLEDGE for ENERGY AUDIT

Concept of

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

ELECTRICITY to WATER

Levels of Assessment

- Level I Assessment – Preliminary Energy Use Analysis & Walk Through Analysis; simple assessment based on available documents and information, physical inspection, and staff interviews to create a baseline and identify obvious energy efficiency measures which are easy to implement
- Level II Assessment – Energy Survey and Analysis; review of data, existing and newly gathered, to identify all energy saving measures and identify high potential measures for further investigation
- Level III Assessment – Detailed Analysis of Capital Intensive Measures; also known as Investment Grade Audit used to give a detailed assessment of costs and benefits derived from capital intensive energy conservation measures

ELECTRICITY to WATER

Steps in an Energy Audit

- Collect and analyze historical energy usage.
- Study pumping systems and their operational characteristics.
- Identify potential modifications that will reduce the energy usage and/or cost.
- Perform an engineering and economic analysis of potential modifications.
- Prepare a rank-ordered list of appropriate modifications.
- Prepare a report to document the analysis process and results.

ELECTRICITY to WATER

Levels of Assessment

- Level I Assessment – Preliminary Energy Use Analysis & Walk Through Analysis; simple assessment based on available documents and information, physical inspection, and staff interviews to create a baseline and identify obvious energy efficiency measures which are easy to implement
- Level II Assessment – Energy Survey and Analysis; review of data, existing and newly gathered, to identify all energy saving measures and identify high potential measures for further investigation
- Level III Assessment – Detailed Analysis of Capital Intensive Measures; also known as Investment Grade Audit used to give a detailed assessment of costs and benefits derived from capital intensive energy conservation measures

ELECTRICITY to WATER

Level I Assessment

- Purpose for undertaking:
  - Gain a full understanding of how energy is being consumed and the associated costs
  - Report on energy use to internal or external stakeholders
  - Find energy conservation programs for immediate and future consideration
  - Identify projects for future energy reduction
  - Set targets for energy reduction
- Results:
  - Baseline of energy use
  - Forecast of future energy use based on current / historical consumption
  - Identification of no/low cost measures for energy reduction
  - List of potential projects for future investigation
  - Detailed benchmarking for accurate comparison to other facilities and own past performance
  - Preparation for next level of assessment

ELECTRICITY to WATER

Level II Assessment

- Purpose for undertaking:
  - Desire to take advantage of energy and cost savings from a wider range of projects
  - Creation of a full energy conservation program
- Results:
  - Evaluation of all potential energy conserving operational changes and capital investments available
  - Listing of capital projects that require further investigation prior to implementation
  - Preparation for next level of assessment

ELECTRICITY to WATER

Level III Assessment

- Purpose for undertaking:
  - Desire to undertake significant capital projects to improve energy efficiency based on projects identified in previous levels of assessment
  - May include gaining access to external financing under performance contract.
- Results:
  - Detailed information provided so that owners have a high level of confidence in decision making regarding significant capital investment
  - May include implementation of capital intensive EE measures under performance contract.

ELECTRICITY to WATER

Method & Approach for Water Systems

- The audit involves carrying out various measurements and analysis of the following systems to assess losses and the potential for energy efficiency improvements:
  - Pumps & Pumping Systems
  - Electrical Systems
  - Electric Drives

ELECTRICITY to WATER

Measurement

- Data collection
  - Specifications of pumps and motors
  - Diagram of water distribution air network
  - Water pressure required for the system
  - Number of pumps in operation
  - Design/specified water temperature required
- Water flow rate of pumps at various operating conditions
  - Individual
  - Parallel
- Water flow velocity in pipe lines
- Suction & discharge pressure of pump

ELECTRICITY to WATER

Data Analysis and Energy Conservation Measures (ECMs)

- Full written description of each ECM to include:
  - Existing conditions and data collection approach (snapshot, short-term, or long-term measurement of data)
  - Recommendations. Include discussion of facility operations and maintenance procedures that will be affected by ECM installation and implementation.
- Baseline energy use:
  - Summary of all utility bills
  - Base year consumption and description of how established

ELECTRICITY to WATER

Data Analysis and Energy Conservation Measures (ECMs)

- Savings Calculations:
  - Base year energy use and cost
  - Post-retrofit energy use and cost
  - Savings estimates including analysis methodology, supporting calculations, and assumptions used
  - Operations and maintenance savings
  - If manual calculations are employed, formulas, assumptions, and key data shall be stated.

ELECTRICITY to WATER

Data Analysis and Energy Conservation Measures (ECMs)

- Cost Estimate:
  - Engineering/design costs
  - Contractor/vendor estimates for labor, materials, equipment; etc
  - Construction management fees
  - Commissioning costs
  - Other costs/fees

ELECTRICITY to WATER

Energy Audit Report Format

- Executive Summary
- Background
- Energy Scenario
- Inventories
- Baseline Parameters & Adjustments
- System Mapping Details
- List of Potential Energy Saving Projects
- Detailed Financial Analysis (Payback, NPV, IRR)
- Details of Approved Projects
- M&V Plan
- Risk Assessments & Mitigation Plan
- Annexure

Responsibility Matrix

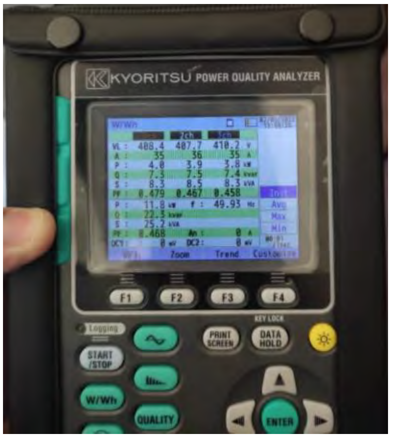
S.No.	Designation	Responsibility
1.	Director	Approve and Present
2.	Executive Engineer	Verify and Prepare Recommendations for Improvement
3.	Sub-Divisional Officer	Supervise Energy Audit
4.	Sub-Engineer / Supervisor	Perform Energy Audit

Equipment Required for Energy Audit

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

Power Analyzer:

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



BASIC KNOWLEDGE for ENERGY AUDIT

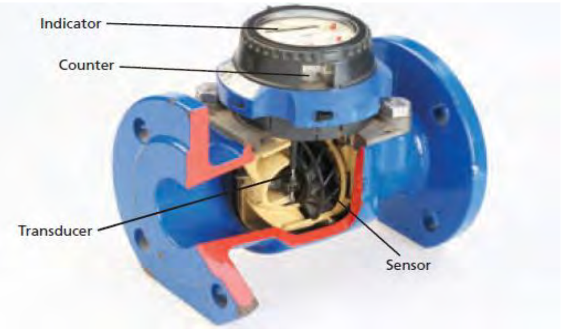
✓Turbine Meters

✓Ultra Sonic Flow Meters

✓Electromagnetic Meters

Turbine meter

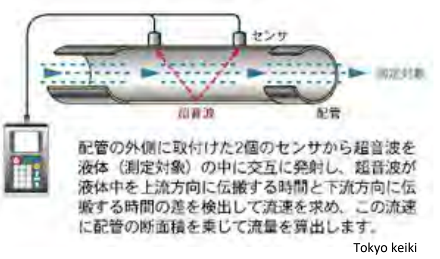
- ✓These meters have a rotating element that turns with the flow of water.
- ✓Volume of water is measured by the number of revolutions by the rotor.



Ultrasonic meters

- ✓Sending sound waves from 2 sensor (transmitter) diagonally across the flow of water in the pipe.
- ✓The time difference between 2 direction to be converted to flow velocity.

(there is Doppler shift method, too)



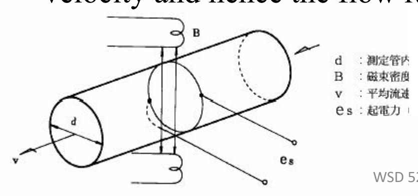
Tokyo keiki

Ultrasonic flowmeter (time transit)

Electromagnetic meter

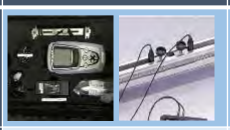
✓Induce magnetic field in the bore by coils outside of the flow channel. When water flows the magnetic field, electromotive force (Voltage) is induced.

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



Electromagnetic flowmeter

BASIC KNOWLEDGE for ENERGY AUDIT

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

BASIC KNOWLEDGE for ENERGY AUDIT

Principles of Measurement

Pressure measurement


Ultrasonic Flow meter:

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

Pressure Gauge

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

Water level meter

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

Tachometer

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

Digital Thermometer

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

Vibration meter

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

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

Date(yyyy-mm-dd): - -
Time(in 24 hour scale) :
Location:

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

Diameter of Discharge Pipe (m)

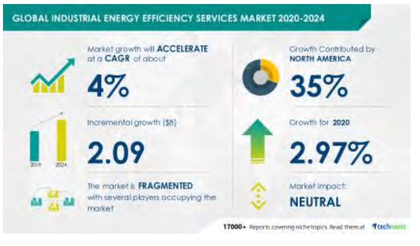
Sr.#	Parameter	Unit	Method	Figure	Criteria for TW WASA Lahore
1	Discharge Pressure (p_d)	bar	Pressure Gauge		> 2 (WASA standard)
2	Flow (Q)	m^3/h	Ultrasonic Flow meter		To Be -20% to +10% of Design Flow
3	Dynamic Water Level (hpl)	m	Level Meter		according to design
4	Static Water Level (hpl)	m	Level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

FINDINGS & RECOMMENDATIONS

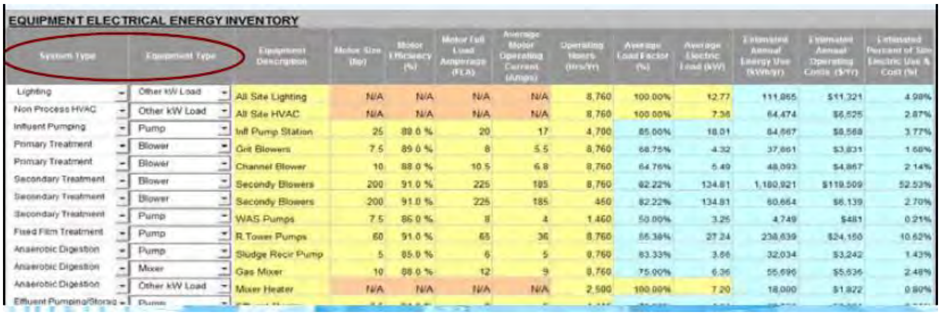
Surveyer: Attendance:

Development of Energy Management Plan

- Introduction
- Installed Capacity
- Calculations
- Analyzing and Implementing Findings
- Electric Utility Billing Structures
- Energy Benchmarking
- Energy Efficiency improvement Measures
- Implementing Findings



Energy Assessment Tool



EQUIPMENT ELECTRICAL ENERGY INVENTORY

System Type	Equipment Type	Equipment Description	Motor Size (hp)	Motor Efficiency (%)	Motor Full Load Amperage (FLA)	Average Motor Operating Current (Amps)	Operating Hours (Hrs/Yr)	Average Load Factor (%)	Average Electric Load (kW)	Estimated Annual Energy Use (kWh/yr)	Estimated Annual Operating Costs ($/Yr)	Estimated Percent of Site Electric Use & Cost (%)
Lighting	Other kW Load	All Site Lighting	N/A	N/A	N/A	N/A	8,760	100.00%	12.77	111,865	$11,321	4.98%
Non Process HVAC	Other kW Load	All Site HVAC	N/A	N/A	N/A	N/A	8,760	100.00%	7.36	64,474	$6,525	2.87%
Influent Pumping	Pump	Infl Pump Station	25	89.0 %	20	17	4,700	85.00%	18.01	84,667	$8,568	3.77%
Primary Treatment	Blower	Grit Blowers	7.5	89.0 %	8	5.5	8,760	68.75%	4.32	37,861	$3,831	1.68%
Primary Treatment	Blower	Channel Blower	10	88.0 %	10.5	6.8	8,760	64.76%	5.49	48,093	$4,867	2.14%
Secondary Treatment	Blower	Secondy Blowers	200	91.0 %	225	185	8,760	82.22%	134.81	1,180,921	$119,509	52.53%
Secondary Treatment	Blower	Secondy Blowers	200	91.0 %	225	185	450	82.22%	134.81	60,664	$6,139	2.70%
Secondary Treatment	Pump	WAS Pumps	7.5	86.0 %	8	4	1,460	50.00%	3.25	4,749	$481	0.21%
Fixed Film Treatment	Pump	R.Tower Pumps	60	91.0 %	65	36	8,760	55.38%	27.24	238,639	$24,150	10.62%
Anaerobic Digestion	Pump	Sludge Recir Pump	5	85.0 %	6	5	8,760	83.33%	3.66	32,034	$3,242	1.43%
Anaerobic Digestion	Mixer	Gas Mixer	10	88.0 %	12	9	8,760	75.00%	6.36	55,696	$5,636	2.48%
Anaerobic Digestion	Other kW Load	Mixer Heater	N/A	N/A	N/A	N/A	2,500	100.00%	7.20	18,000	$1,822	0.80%
Effluent Pumping/Storag	Pump	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Contact:

Engr. Jawad Shahid

Advanced Energy Audit

By

Jawad Shahid

(Vice Principal)

The Urban Unit

ALJAZARI ACADEMY

JICA

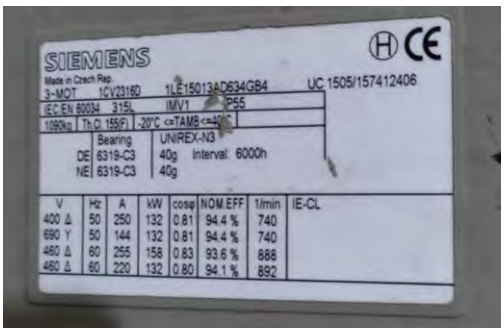
Basic O&M of Pumping Machinery

- Energy Audit:

- Purpose: In order to evaluate the pumping efficiency and monitor changes over time

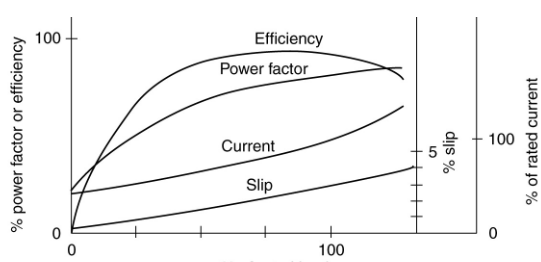
Causes of Low Power Factor For Induction Motor

- What Could be the reason for low Power Factor in 3 Phase Induction Motors?



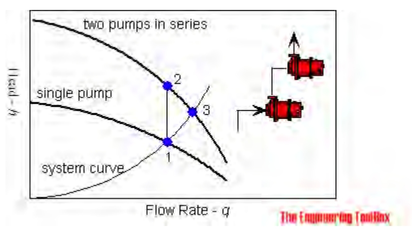
Causes of Low Power Factor For Induction Motor

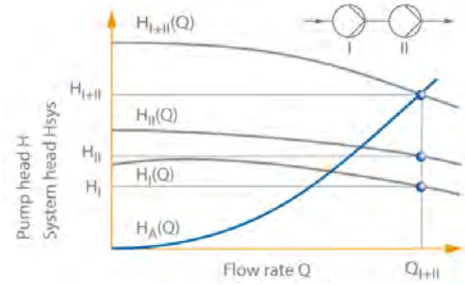
- For Induction motors, the pf is usually extremely low (0.2 - 0.3) at light loading conditions and it is 0.8 to 0.9 at full load.
- In some cases, due to improper wiring or electrical accidents, a condition known as 3-φ power imbalance occurs. This results in low power factor too.



Series Pump operation

- When two centrifugal pumps (I and II) are operating in series, the head (HI+II) is the sum of the individual pumps' heads and the flow rate remains the same.

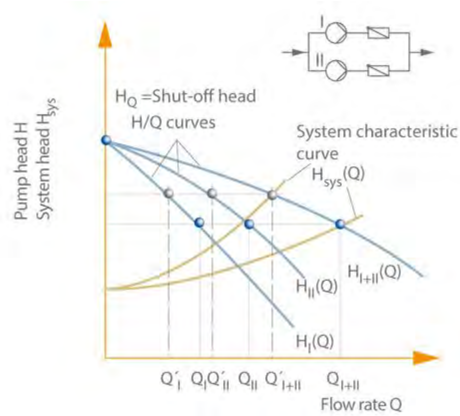




Series operation: Series operation of two centrifugal pumps I and II with any type of characteristic curves

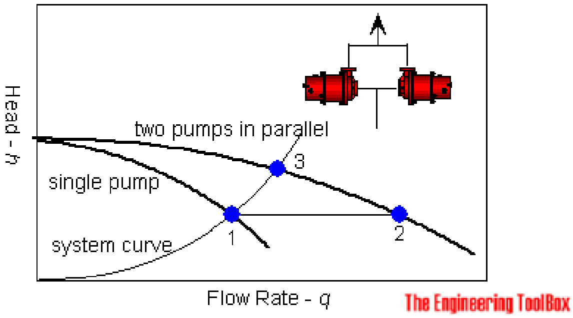
Parallel Pump Operation

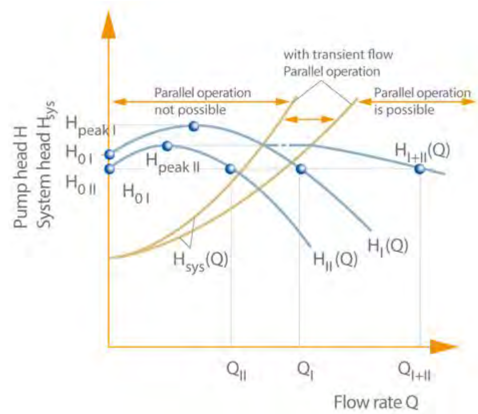
- If two centrifugal pumps I and II are operated in parallel, the flow rate QI+II is the sum of the flow rates of the individual pumps at the same head, i.e.:



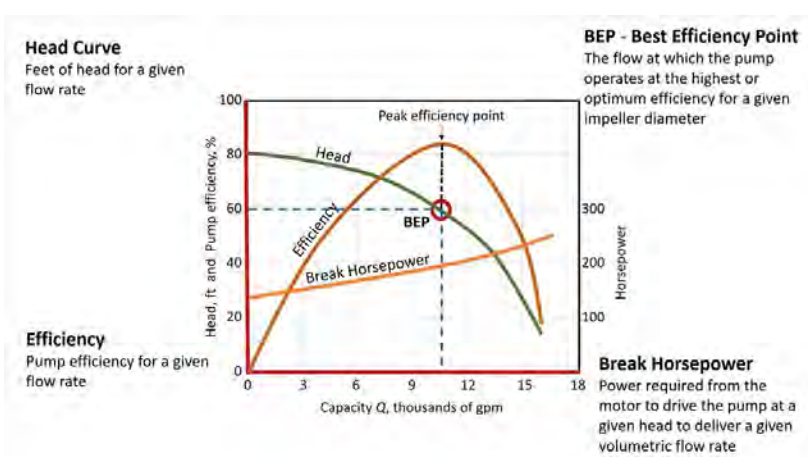
Parallel operation: Two centrifugal pumps I and II with stable characteristic curves

Parallel Pump Operation

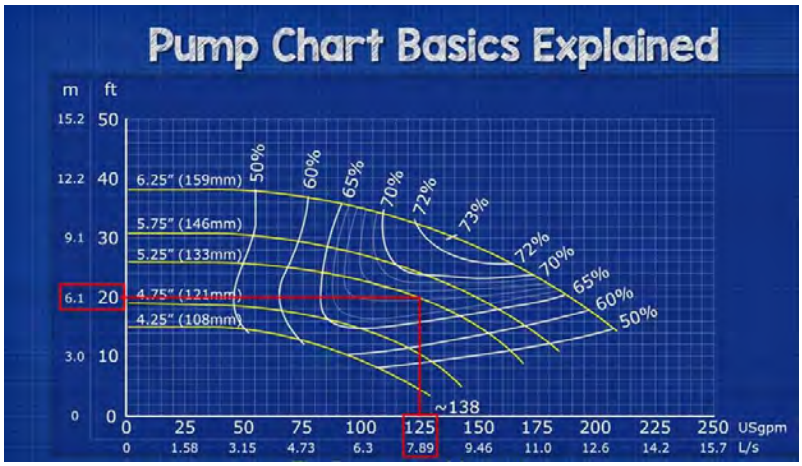




Q-H Curve



Pump Efficiency



Flow and current relationship

- With Increase in flow, pressure will decrease and power consumption will increase

- With Decrease in flow, pressure will increase and power consumption decreases.

Effect of over sizing and under sizing the motor on power consumption

- Undersize:
  - Overload
  - Lower Flow
  - Higher Power Consumption

- Oversize:
  - Underutilization
  - V. Low Power Factor
  - Energy Wastage

Selecting the wrong size motor

- What are the power demands of the pump?
- What will typical operation look like for this pump?
- Will the pump be operated on a variable frequency drive (VFD)?

ALJAZARI ACADEMY

The Urban Unit

Urban Sector Planning & Management Services Unit (Pvt.) Ltd.

JICA

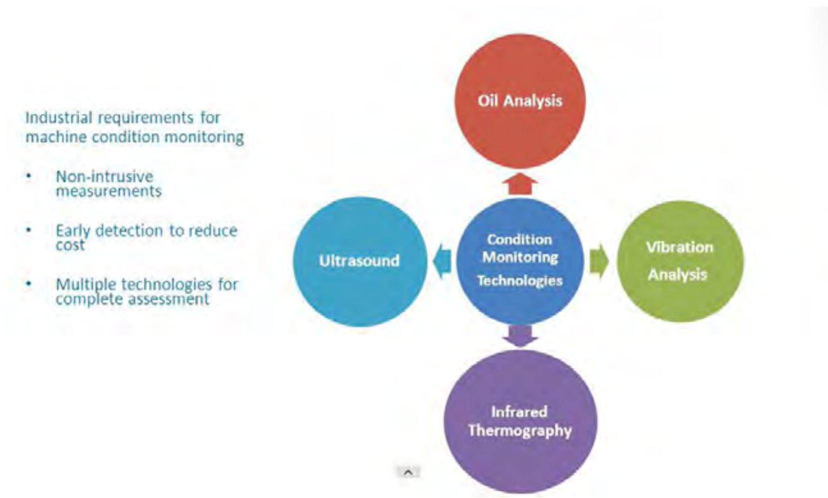
Vibration Analysis

Vibration

- Vibration is a back and forth movement of a structure, It can also be referred to as cyclical movement

- Vibration Monitoring:
  - The Vibrations that are felt generally come for the forces inside the machine

Machine Condition Monitoring Technologies

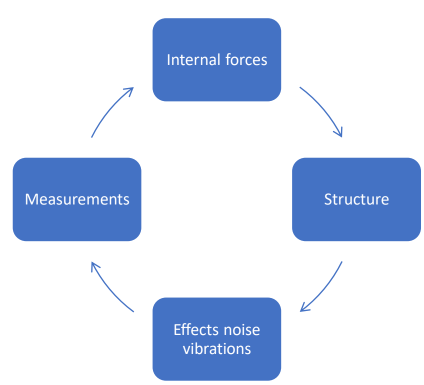


Vibration Monitoring Fundamentals

- Principles of Vibration analysis

Major Causes:

- Unbalancing
- Misalignment
- Bearings
- Gears Magnetic Faults
- etc



Cost of machine failures

What Does vibration Indicate?

- The Vibrations produced in a machine are a best indication of Machine health

- Indication of Machine failures

Common Problems that Generate Vibration

1. Misalignment
2. Unbalance
3. Worn belts & pulleys
4. Bearing Defects
5. Hydraulic Forces
6. Aerodynamic Forces
7. Reaction Forces
8. Reciprocating Forces
9. Bent Shafts
10. Rubbing
11. Gear Problems
12. Housing Distortion
13. Certain Electrical Problems
14. Frictional Forces

Vibration Monitoring

- Permanent Vibration Sensors
  - Permanent Sensors installed
- Periodic Vibration Measurement
  - Handheld Vibration measurement device

Vibration Monitoring

- Whenever possible, make measurements in the horizontal (H), vertical (V), and axial (A) directions of each bearing.
- Monitoring points should be marked, and data on the same locations are always taken
- In case of Multiple Pumps installed the same scenario be created for all measurements

Vibration Limits

- For Motors less than 200kW ….8.5 mm/s
- For Motors above 200 kW …… 9.5 mm/s

The permissible vibration limits for electric motors can be found in the ISO 10816-3 standard. The NEMA and IEC standards also establish some acceptance criteria.

WASA field Issues

Suggested Improvement

Suggested Improvement

Suggested Improvements

Suggested Improvements

Suggested Improvements

Current Conditions

Suggested Improvement

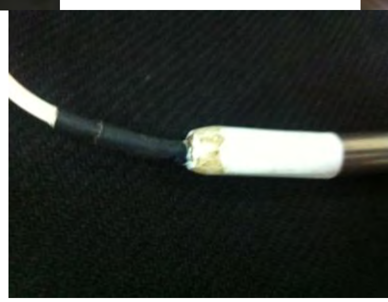
Suggested Improvement

WASA FIELD ISSUES

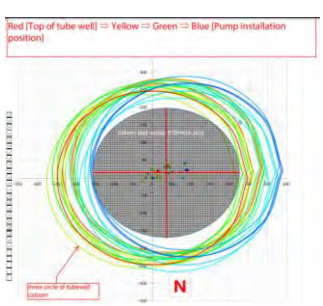
Water Level Indicator Usage Issue

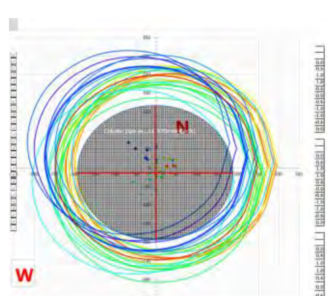
Water Level Indicator Usage Issue

Water Level Indicator Usage Issue



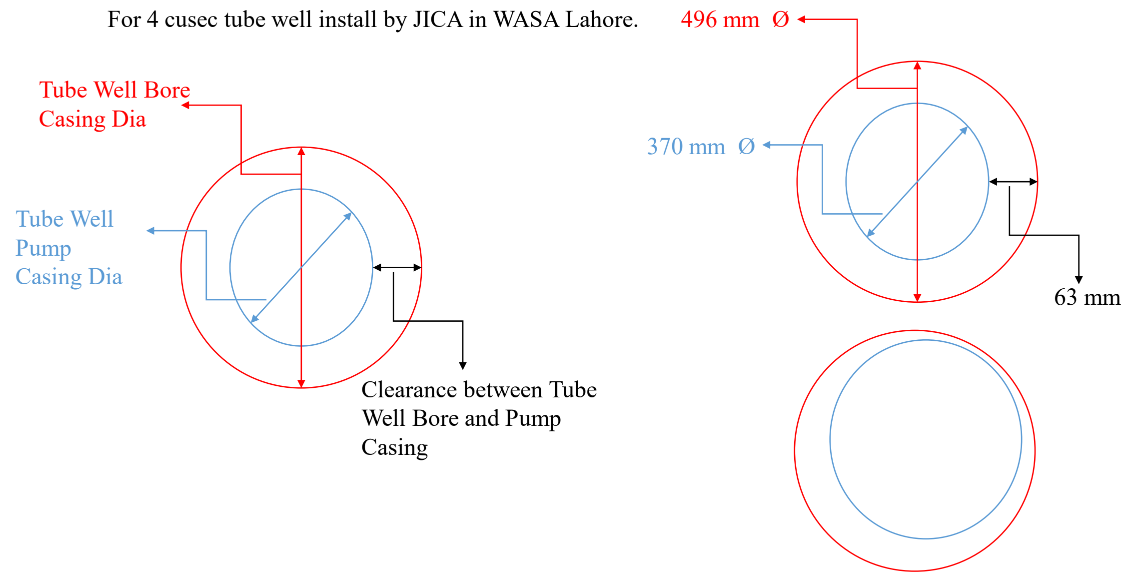
Water Level Indicator Usage Issue





Water Level Indicator Usage Issue

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



Water Level Indicator Usage Issue

Valves maintenance issue in WASAs

- Cracked gasket

17

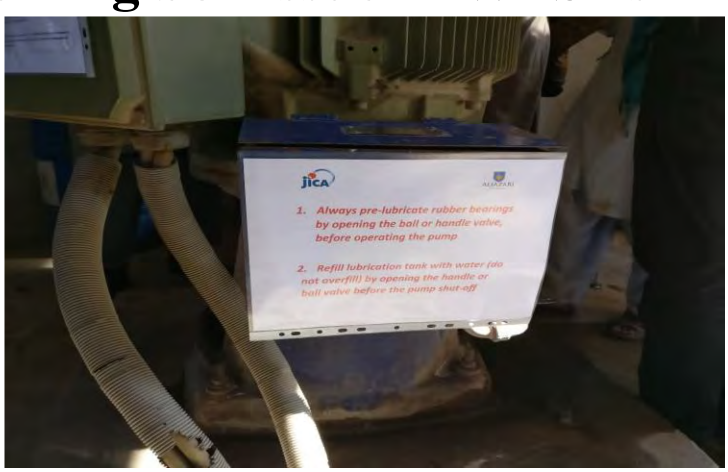
Valves maintenance issue in WASAs

- Absence of balls in air release valves

18

Lubricating box issue in WASAs

Lubricating box issue in WASAs



Thank you

Engr. Jawad Shahid

Operations and Maintenance Plan

The Urban Unit

ALJAZARI ACADEMY

PRMP

Operations and Maintenance Plan

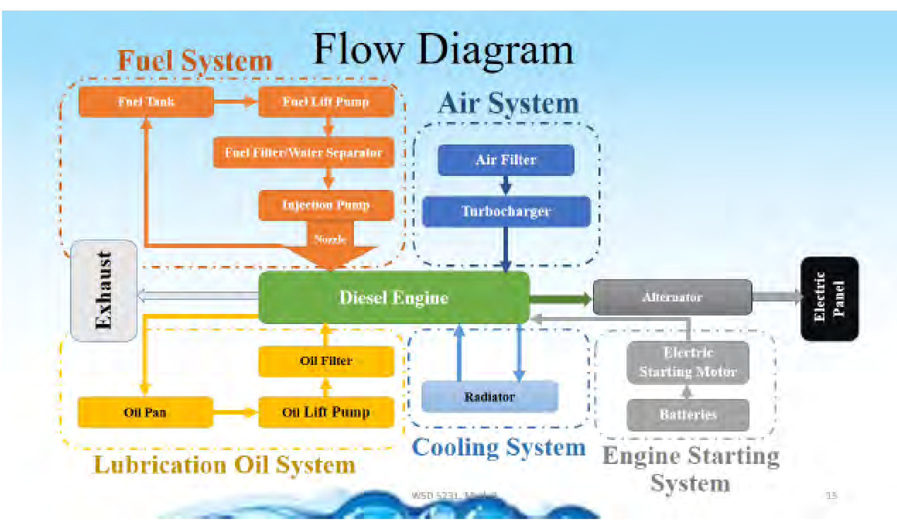
- Operations and Maintenance are the decisions and actions regarding the control and upkeep of property and equipment

    i. Actions focused on scheduling, procedures, and work/systems control and optimization

    ii. Performance of routine, preventive, predictive, scheduled and unscheduled actions aimed at preventing equipment failure

Maintenance Spectrum

Step-I Process Description and Process Flow Diagram



Step-II Equipment Description

- In Case of Tube well

Step-III Operating Procedure

- Submersible Pump Startup & Operation
  - Check water level in bore hole.
  - Check valves (open).
  - Check voltage range for 3-Phase motor.
  - Start up the 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.

Step-III Operating Procedure

- Maintaining procedure log

S.No.	Procedure Description	Procedure No.
1.	Operation of Tubewell	WASA/LAH/44
2.	Gland Packing Replacement	KSB/WASA/LAH/77
3.	MCU Thermal and Insulation Test	PEMPAK/WASA/LHR/22
4.	Energy Audit For Tubewell 4 cfs, JICA	WASA/ELEC/LAH/11

Step-IV Preventative Maintenance Program

S.No.	Equipment	Maintenance	Frequency
1.	Fan Belt of Generator	Visual Inspection	Monthly
2.	Pump Motor Temperature Check	Motor Thermal Check	Quarterly
3.			

Step-IV Evaluation of Facility

- Evaluation of Pumping Facility, Tubewell

S.No.	Procedure Description	Procedure Title
1.	**Evaluation of Motor**	Insulation Test for winding
		Thermal Test for overheating
		RPM Test
		Vibration Test
2.	**Evaluation of Pump**	Flow / Head
		Leakage
		Unusual noise/ vibration

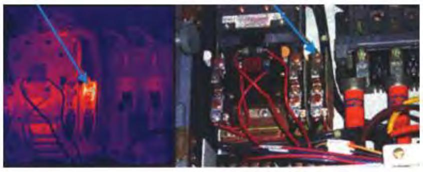
Step-IV Evaluation of Facility

- Evaluation of Pumping Facility, Tubewell

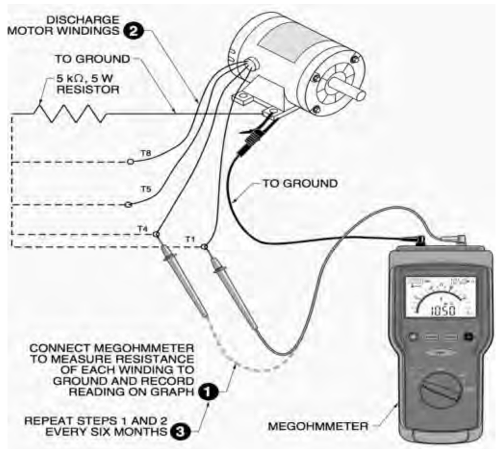
S.No.	Procedure Description	Procedure Title
3.	**Evaluation of Motor Control Unit**	Insulation Test for Wiring and components
		Earth Resistance Test
		Thermal Test for overheating
		Lamp test for warning signs
4.	**Evaluation of Valves**	Check operation of Air Release Valve
		Check operation of Non return Valve
		Check Operation of Gate Valve
5.	**Tubewell Chamber Evaluation**	Visual Inspection

Step-IV Evaluation of Facility

- Evaluation of Pumping Facility, Tubewell

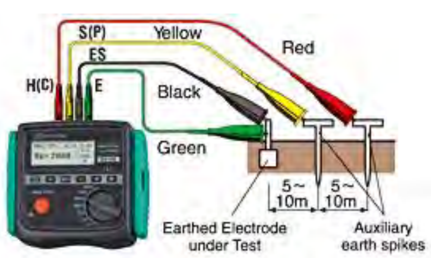


Overloaded contacts show different temperature profiles indicating
one contact seeing much greater load, a potentially unsafe situation.



Step-IV Evaluation of Facility

- Evaluation of Pumping Facility, Tubewell



Earth Resistance Test

Vibro-meter

Contact and Non Contact type Tachometer

Step-IV Evaluation of Facility

- Evaluation of Pumping Facility, Tubewell

Ultrasonic Flow meter

Step-IV Report Writing

- Annual Maintenance Plan

Daily and Periodic Maintenance Sheet

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

Annual Maintenance plan

- Step-I Process Description and Process Flow Diagram
- Step-II Equipment Description
- Step-III Operating Procedure
- Step-IV Preventative Maintenance Program (Evaluation of Facility)
- Maintenance plan

Contact:

Engr. Jawad Shahid

ENERGY AUDIT INPUT FORM (For Site)

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

Preventive Maintenance Sheet for Electrical Facility

Site Name :

Sub Division :

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

Evaluation Criteria
✔: Good
✖: No care at all or need to be newly installed
Δ: Need to be improved
━: Not available to be checked

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

Preventive Maintenance Sheet for Electrical Facility

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

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

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

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

- Remarks -

Check List of Standard Operation Procedure for Electrical Facility

Approved by :

Inspected by :

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

Rated Voltage (V) ______________**Rated Current(A)** ___________

Efficiency_____**Power Factor**_______**RPM**_________

Evaluation Criteria

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

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

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

- Remarks -

Check List of Standard Operation Procedure for Electrical Facility

Evaluation Criteria

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

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

			Document			Visual (Outside)						Visual (Inside)				Operation	
			Operation Record	Drawings	Vender Manual	Identifications of Lamp/Switch	Status/Fault Indication Lamps	Ampere Meter	Voltage Meter	Status Selector Switch		Cleanliness	Intrusion Path	Bypass-Circuit	Neatness of cabling	How to operate changeover switch	Frequency of Start/Stop
			Compare with the sample	Pump installation, electrical line diagram	Pump/ Panel devices	all lamps /switches have name tag	all lamps are visibly bright enough	Proper functioning and zero adjustment	Proper functioning and zero adjustment	Ampere	Voltage	No dust, sand, spider's nest, insect, small animals	No hole/crack to let foreign matters come in	No bypass / burnt mark		Turn off by breaker or switch first.	Maximum 2-3 times/hour
1	Disposal Station, Chungi # 9, Panel # 2	28/03/2017	✓	△	×	✓	✓	✓	-	✓	-	△	△	✓	✓	✓	✓
2	Disposal Station, Chungi # 9, Panel # 4	28/03/2017	✓	△	×	✓	✓	✓	-	△	-	△	△	△	△	✓	✓
3	Disposal Station, Chungi # 9, Panel # 7	28/03/2017	✓	△	×	✓	✓	△	-	△	-	△	△	✓	△	✓	✓
4	Disposal Station, Chungi # 9, Panel # 8	28/03/2017	✓	△	×	✓	✓	△	✓	△	-	✓	△	✓	✓	✓	✓
5	Disposal Station, Chungi # 9, Panel # 11	28/03/2017	✓	△	×	✓	**Off lamp is not working**	△	-	△	-	△	△	✓	✓	✓	✓
Total Numbers of items required to be replaced*							1			4							

- Remarks -

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

Motor Specification:

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

Motor Specification:

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

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

Device Inspection Sheet

Approved by :

Inspected by :

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

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

Power Factor_______**RPM**_________

Evaluation Criteria

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

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

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

- Remarks -

Device Inspection Sheet

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

Sr. No.	Site /Pump Name	Inspection Date	Continuity Test of components (Using Clamp Meter)									Relays Adjustments					
			Circuit Breakers					Magnetic Contactor			Fuse	Over/Under Voltage Relay			Over Current (Thermal) Relay		Y-Δ Timer
			MCCB	MCB 1	MCB 2	MCB 3	MCB 4	K1	K2	K3		Under Voltage Tripping Function	Over Voltage Tripping Function	±10% of rated voltage of motor	Tripping Function	Value Set	Not less than 5 seconds
1	Disposal Station, Chungi # 9, Panel # 2	28/03/2017	✓	✓	✓	✓	✓	✓	✓	✓	-	×	×	-	×	-	✓
2	Disposal Station, Chungi # 9, Panel # 4	28/03/2017	-	×	✓	✓	✓	✓	✓	×	-	×	×	-	×	-	✓
3	Disposal Station, Chungi # 9, Panel # 7	28/03/2017	✓	×	△	✓	✓	✓	✓	✓	-	×	×	-	×	-	✓
4	Disposal Station, Chungi # 9, Panel # 8	28/03/2017	✓	✓	✓	✓	✓	✓	✓	✓	-	×	×	-	✓	-	✓
5	Disposal Station, Chungi # 9, Panel # 11	28/03/2017	✓	△	△	△	✓	✓	✓	✓	-	×	×	-	×	-	✓
Total Numbers of items required to be replaced*			0	3	2	1	0	0	0	1	-	5			4		0

- Remarks -

MCB 4 of panel number 2 was malfunctioned and already replaced

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

Operation Time Record (Pump)

Month/Year :　　　／

Date :　　　～

Approved by (Engineer)	
Prepared by (Operator)	

Facility	Items	Unit	Standard/ Rated	Date								Average	Total
				(–)	(–)	(–)	(–)	(–)	(–)	(–)	(–)		
Pump 1	Operating Time	-		: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :	: ~ :		
	Operating Hours	hrs.											
	Chlorine Dosing	Y/N											
	Flow Reading (Start)	m3											
	Flow Reading (Stop)	m3											
	Flow Amount	m3											
	Pressure	MPa											
	Power Factor	%											
	Voltage RY	V											
	YB	V											
	BR	V											
	Ampere R	A											
	Y	A											
	B	A											

Operation Time Record (Generator)

Month/Year : ／

Date : ～

Approved by (Engineer)	
Prepared by (Operator)	

Facility	Items	Unit	Standard/ Rated	Date								Average	Total
				( )	( )	( )	( )	( )	( )	( )	( )		
Generator	Operating Time	-		: ~ :	: ~ :	: ~ :				: ~ :	: ~ :		
	Operating Hours	hrs.											
	Fuel Level (Start)	L											
	Fuel Level (Stop)	L											
	Fuel Consumption	L											
	Voltage RS	V	400										
	ST	V	400										
	TR	V	400										
	Frequency	Hz	50										
	Energy Reading (Start)	KWh											
	Energy Reading (Stop)	KWh											
	Energy Consumption	KWh											

Operation Time Record (Pump)

Month/Year : /

Date : ~

Approved by (Engineer)	
Prepared by (Operator)	

Sr. No.	Date	Shift #	Operating Time		Operating Hours	Chlorine Dosing	Flow Reading (Start)	Flow Reading (Stop)	Flow Amount	Pressure	Power Factor	Voltage			Ampere		
			Turn On	Turn Off	hrs.	Y/N	m3	m3	m3	MPa	%	RY (V)	YB (V)	BR (V)	R (A)	Y (A)	B (A)
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	

Remarks:

Motor Movement Explanation

【Pre Movement Condition】

1 Main Circuit Breaker （TP MCCB A47） : ON
2 Circuit Breaker MCB（A1-A3 SP MCB's） : ON
3 Under/Over Voltage Relay（UV/OV RELEY） : OFF
4 Thermal Relay（O/L RELEY） : OFF

【Movement Explanation】

1 Push Button → ON
2 Power Contactor K3 → ON → Power Souce Voltage Impress To Motor U V W
3 Power Contactor K1 → ON → Motor Connection Is Y Wiring.
（Only 1/√3 Power Voltge Will Impress To Each Phase And Starting Current Will Be Small）
4 Timer（TR） → Condition
5 Timer → ON
6 Power Contactor K2 → ON → Motor Connection Will Change to ΔWiring、
Turn to Normal Operation, Motor Will Run Normally.
7 MOTOR ON Light → ON

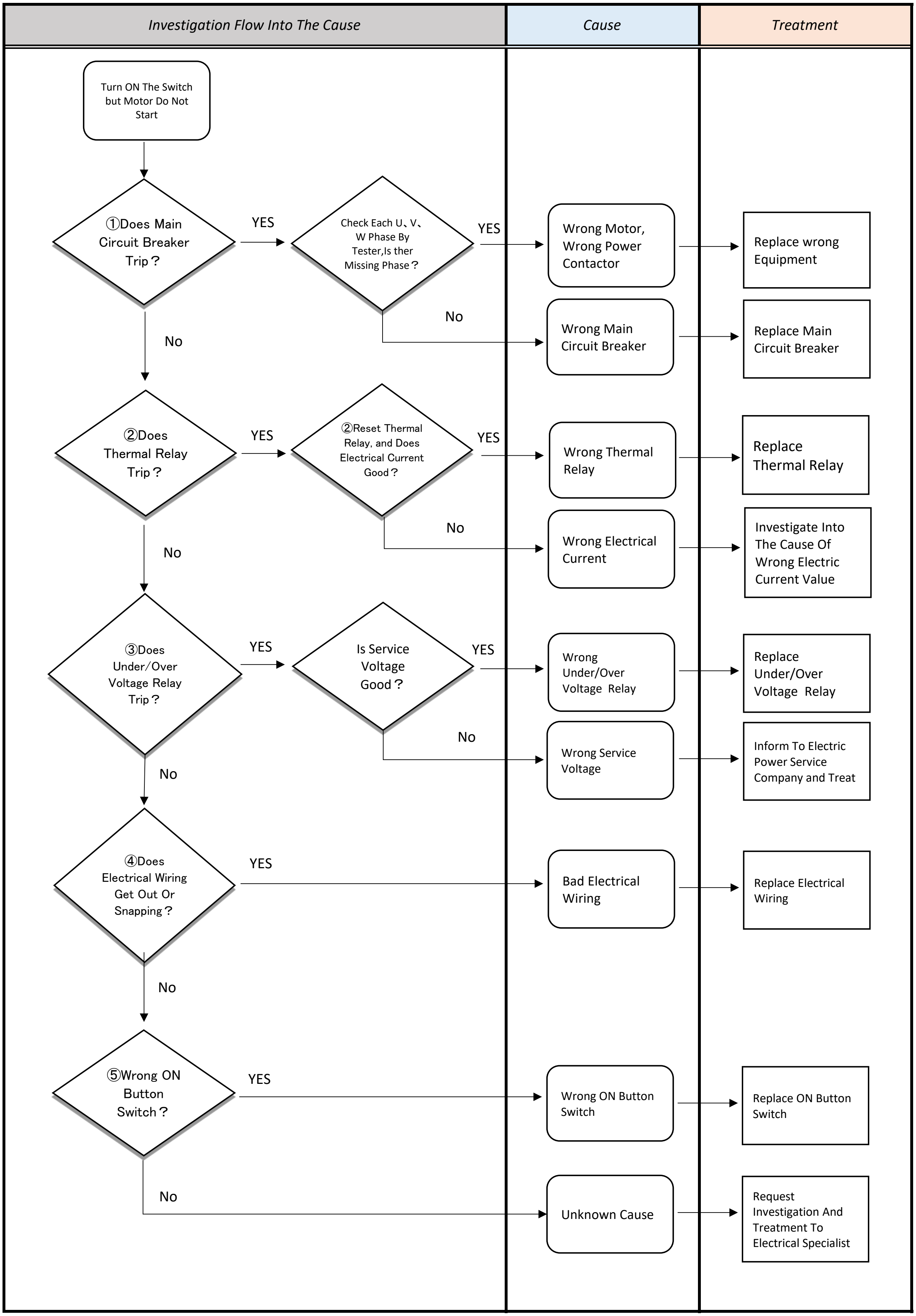
1 Push Button → OFF
2 Power Contactor K1 K2 K3 → OFF
3 Motor → Stop

【Check Items While Motor Running】

1 By ASS（Ammeter Change Over Switch）Check Each Phase Electric Current（U V W）,
Confirm It Shows Under Rated Current.
2 By VSS（Voltage Change Over Switch）,Check The Voltage Of U-V V-W U-W, Confirm It is Normal Value.
3 Chaeck The Water Level Of Motor Drawing Well.

【Other Check Items】

1 Using Insulation Resister Tester, Check theMotor Insulation Resiatant Value.
2 Regular Management Should Be Treated For Motor (for example Oil, Lubricating Water).


Investigation Flow Into The Cause
Cause
Treatment
Turn ON The Switch but Motor Do Not Start
①Does Main Circuit Breaker Trip？
YES
Check Each U、V、W Phase By Tester,Is ther Missing Phase？
YES
Wrong Motor, Wrong Power Contactor
Replace wrong Equipment
No
Wrong Main Circuit Breaker
Replace Main Circuit Breaker
No
②Does Thermal Relay Trip？
YES
②Reset Thermal Relay, and Does Electrical Current Good？
YES
Wrong Thermal Relay
Replace Thermal Relay
No
Wrong Electrical Current
Investigate Into The Cause Of Wrong Electric Current Value
No
③Does Under/Over Voltage Relay Trip？
YES
Is Service Voltage Good？
YES
Wrong Under/Over Voltage Relay
Replace Under/Over Voltage Relay
No
Wrong Service Voltage
Inform To Electric Power Service Company and Treat
No
④Does Electrical Wiring Get Out Or Snapping？
YES
Bad Electrical Wiring
Replace Electrical Wiring
No
⑤Wrong ON Button Switch？
YES
Wrong ON Button Switch
Replace ON Button Switch
No
Unknown Cause
Request Investigation And Treatment To Electrical Specialist

Annex 5.1.48 Training Material for "Leakage Control, Plumbing and Pipe Replacement Plan" in Fall 2022

mWater App
&
QGIS Software

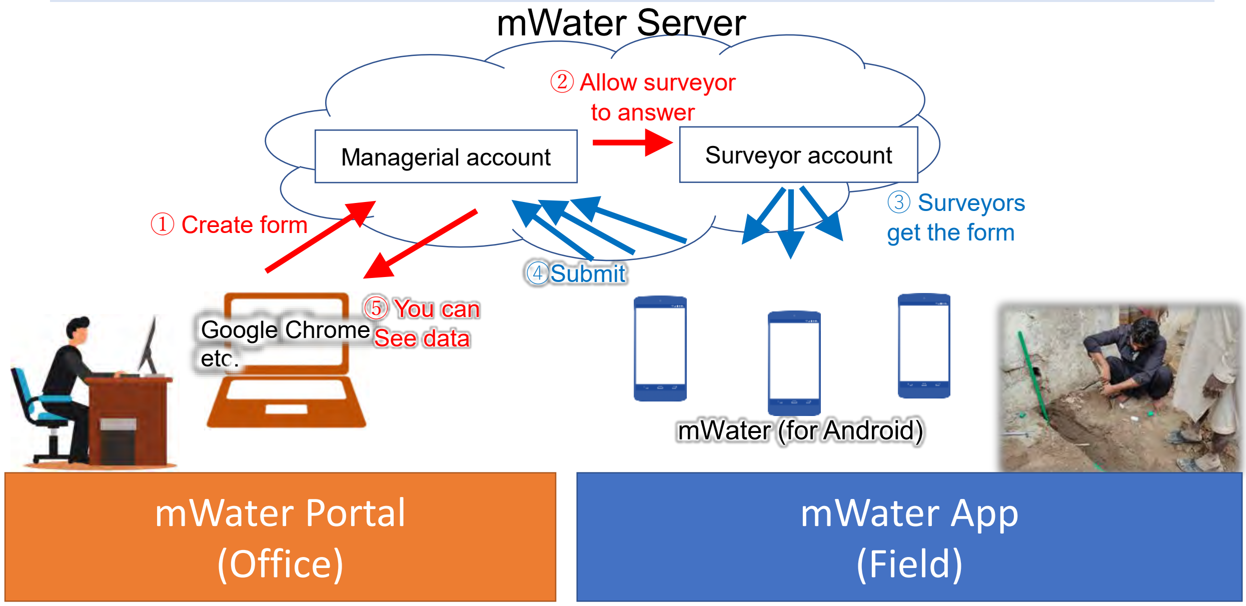
Instructor

Engr. Muhammad Uzair Safdar

Learning Outcomes

- **Understand** key features of M-Water App and Q-GIS software
- **Create** data collection forms related to different assets of water utility
- **Use** of M-Water App for Data Collection and Management
- **Able** to keep record of Data (Leakage/Assets)
- **Know** importance of using Data Collection and Monitoring Tools
- **Present** recorded data in Q-GIS Program

mWater data collection

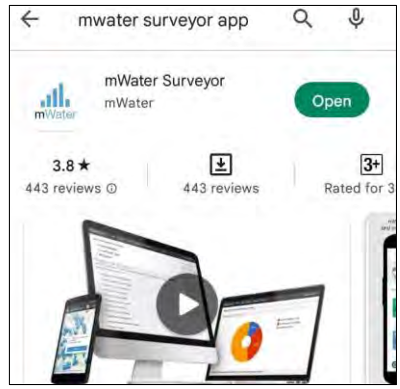


mWater App

(for Android)

mWater App

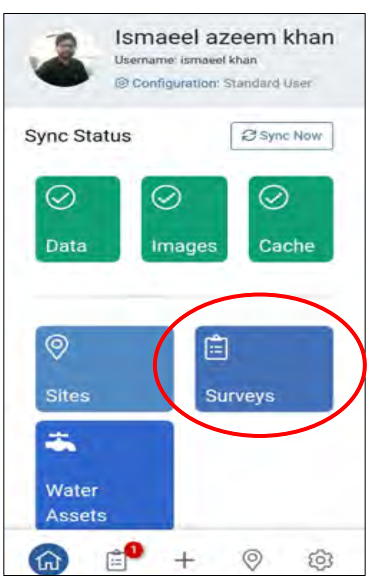
- Download from Play store with the name of **(mWater surveyor)**



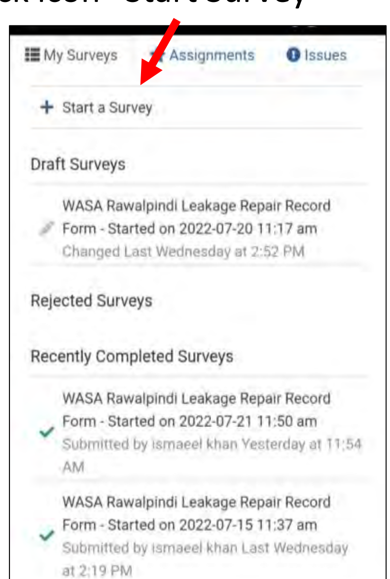
- Made Log-In ID on App and use it for Portal on PC.

mWater App

- After logging in, Click "Survey" icon

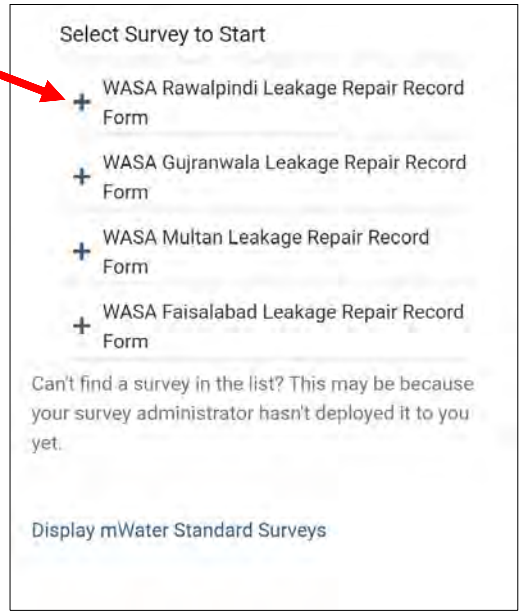


- Click icon "Start Survey"



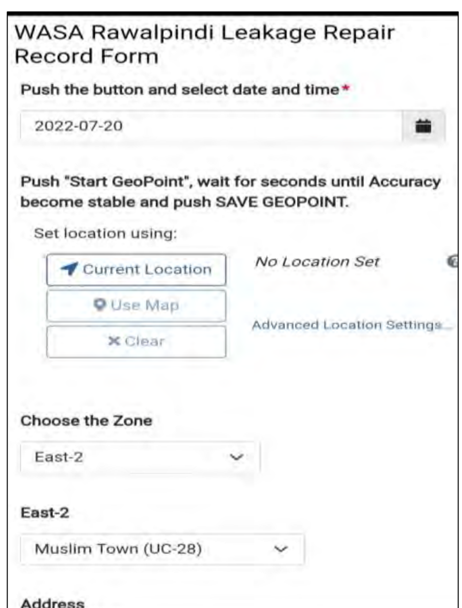
mWater App

- Select Form



mWater App

Put the information on the site, the repair situation etc.



mWater app

- Take photo

  and

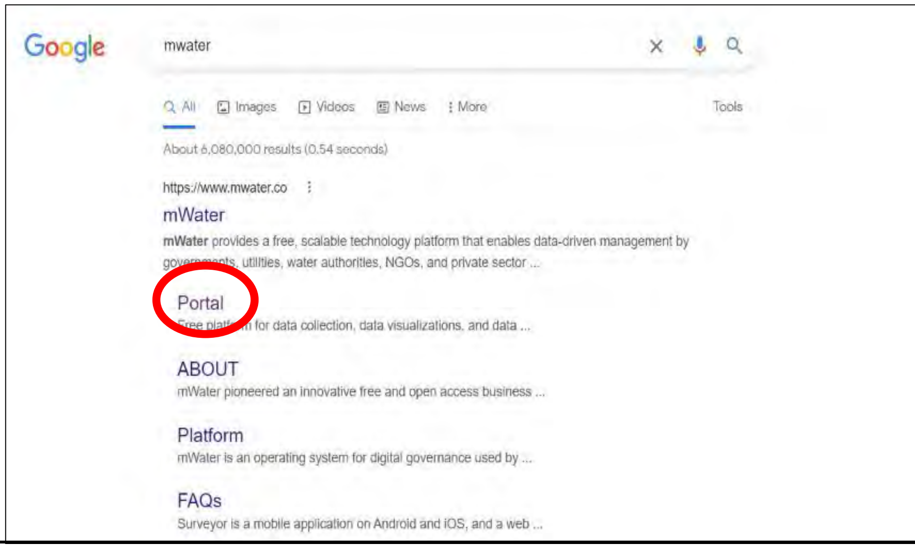
- Click “Submit”.

- When Internet is not available,
  Click “Save for Later”

mWater Portal

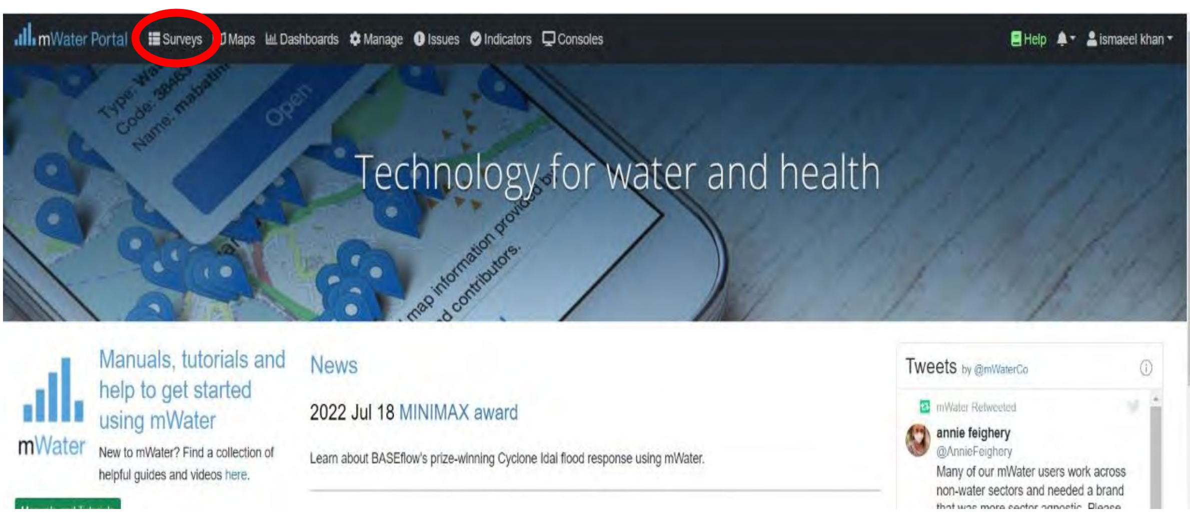
mWater Portal

- After the submission from mWater app, we can see the results on our PC or browser on smartphone or tablet, and analyze the results.



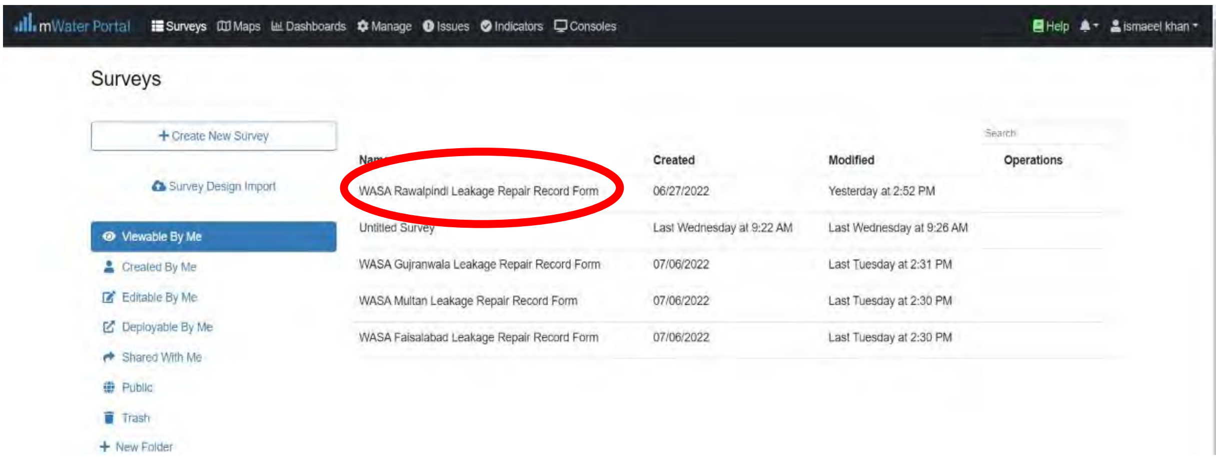
mWater Portal

- After Log in, click on “Survey” ICON.



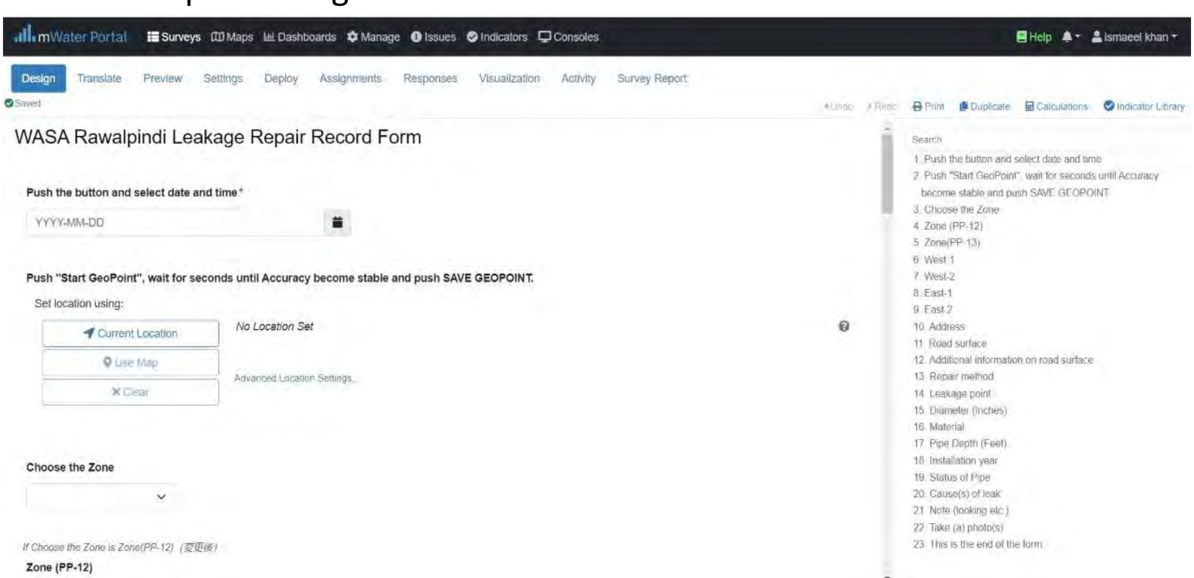
mWater Portal

- We can either use prepared form or create new survey



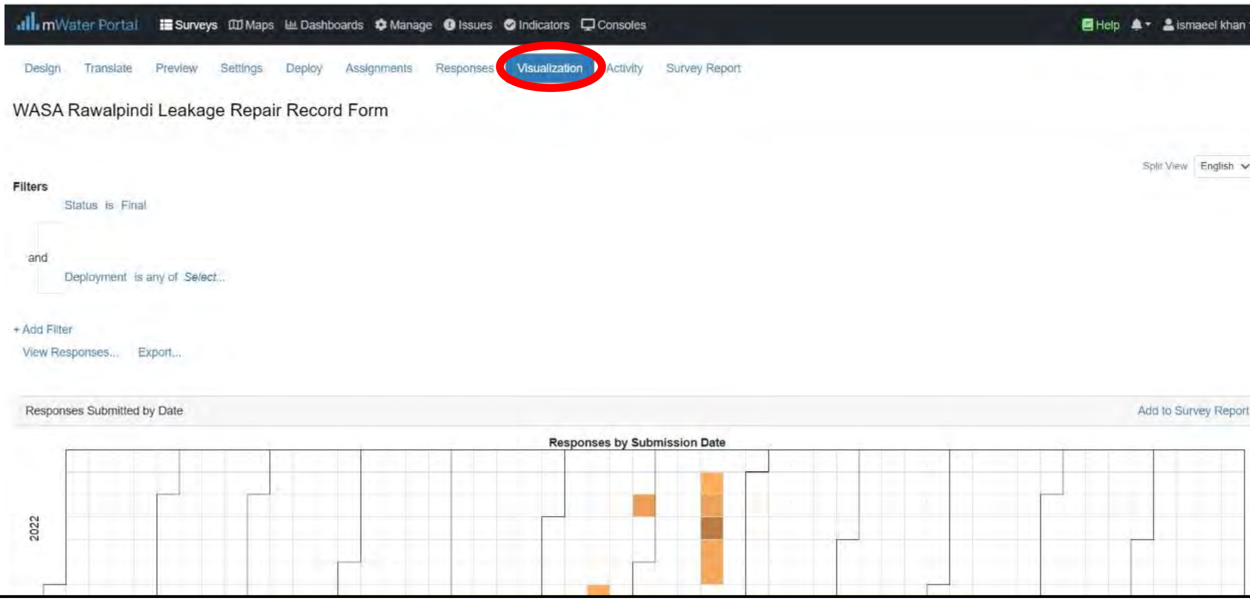
mWater Portal

- Click on repair leakage form



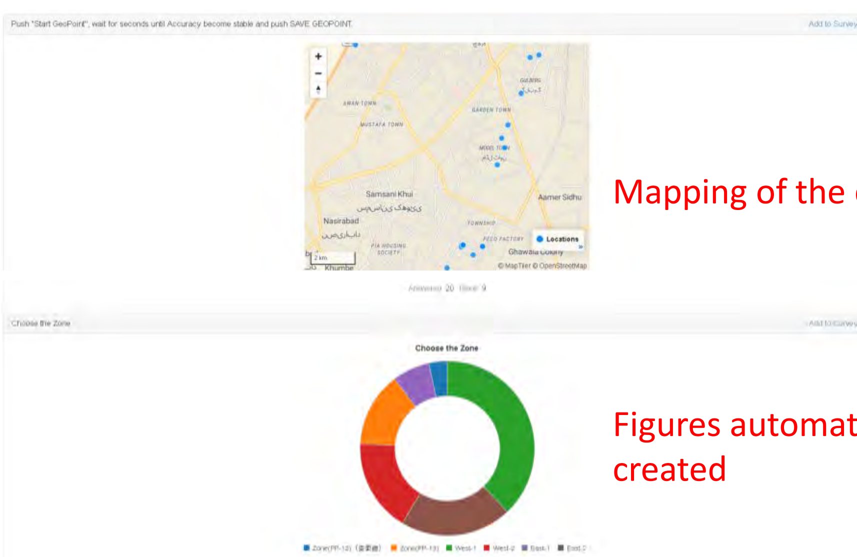
mWater Portal

- To see the form click on visualization



mWater Portal

- Example of Visualized data

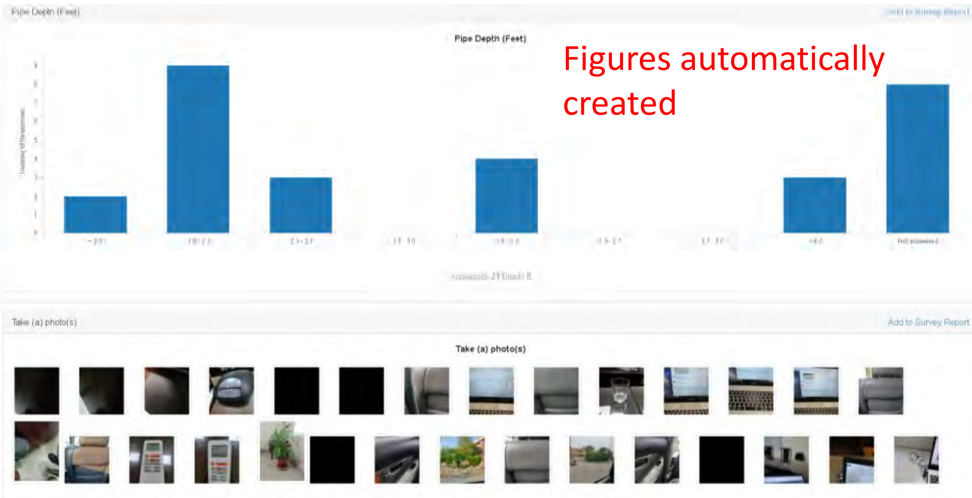


Mapping of the cases

Figures automatically created

mWater Portal

- Example of Visualized data

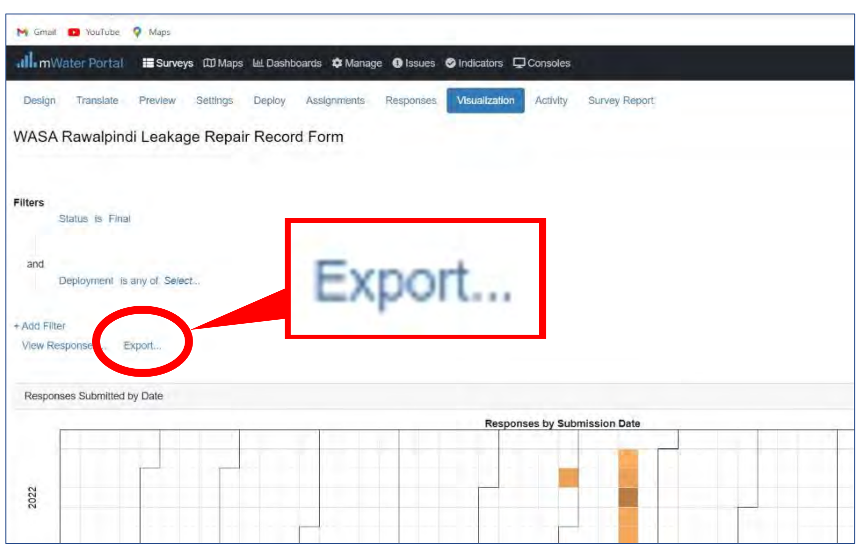


Figures automatically created

Photos

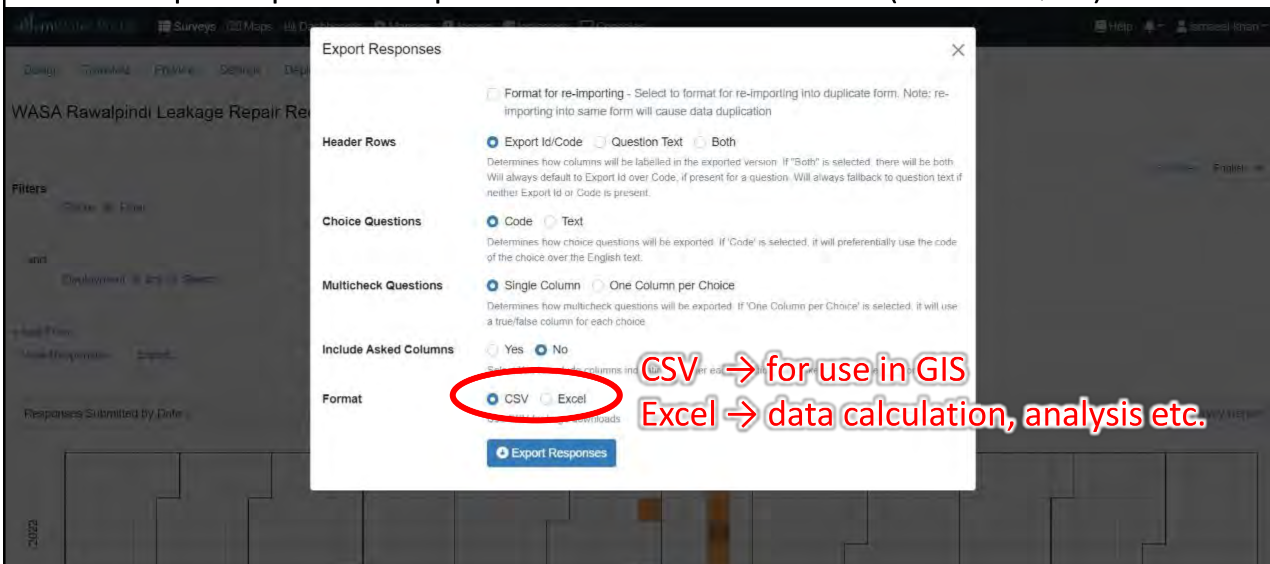
mWater Portal

- We can export file by clicking "Export" option.



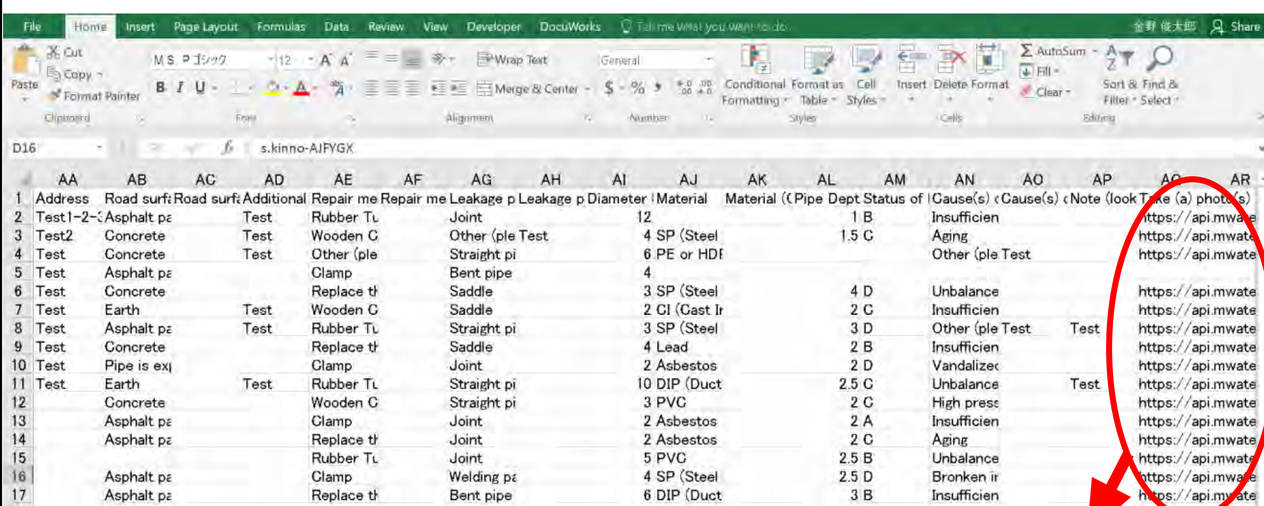
mWater Portal

Click on Export Option to export this file into Excel or CSV (used in QGIS)



Downloaded Excel sheet

(.xlsx or .csv)



	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
1	Address	Road surfa	Road surfa	Additional	Repair me	Repair me	Leakage p	Leakage p	Diameter	Material	Material (	Pipe Dept	Status of	Cause(s)	Cause(s)	Note (look	Take (a) photo(s)	
2	Test1-2-3	Asphalt pa		Test	Rubber Tu		Joint		12			1	B	Insufficien			https://api.mwate	
3	Test2	Concrete		Test	Wooden C		Other (ple	Test	4	SP (Steel		1.5	C	Aging			https://api.mwate	
4	Test	Concrete		Test	Other (ple		Straight pi		6	PE or HDI				Other (ple	Test		https://api.mwate	
5	Test	Asphalt pa			Clamp		Bent pipe		4									
6	Test	Concrete			Replace th		Saddle		3	SP (Steel		4	D	Unbalance			https://api.mwate	
7	Test	Earth		Test	Wooden C		Saddle		2	CI (Cast Ir		2	C	Insufficien			https://api.mwate	
8	Test	Asphalt pa		Test	Rubber Tu		Straight pi		3	SP (Steel		3	D	Other (ple	Test	Test	https://api.mwate	
9	Test	Concrete			Replace th		Saddle		4	Lead		2	B	Insufficien			https://api.mwate	
10	Test	Pipe is exp			Clamp		Joint		2	Asbestos		2	D	Vandalized			https://api.mwate	
11	Test	Earth		Test	Rubber Tu		Straight pi		10	DIP (Duct		2.5	C	Unbalance		Test	https://api.mwate	
12		Concrete			Wooden C		Straight pi		3	PVC		2	C	High press			https://api.mwate	
13		Asphalt pa			Clamp		Joint		2	Asbestos		2	A	Insufficien			https://api.mwate	
14		Asphalt pa			Replace th		Joint		2	Asbestos		2	C	Aging			https://api.mwate	
15					Rubber Tu		Joint		5	PVC		2.5	B	Unbalance			https://api.mwate	
16		Asphalt pa			Clamp		Welding pa		4	SP (Steel		2.5	D	Bronken ir			https://api.mwate	
17		Asphalt pa			Replace th		Bent pipe		6	DIP (Duct		3	B	Insufficien			https://api.mwate	
18																		

All the answers are shown in the table

Open the image on web browser

QGIS

(PC Software)

QGIS Software

Index

- Use of QGIS software
- How to see mWater data and show them on **QGIS**.
- How to utilize the data

Step-1: How to install QGIS

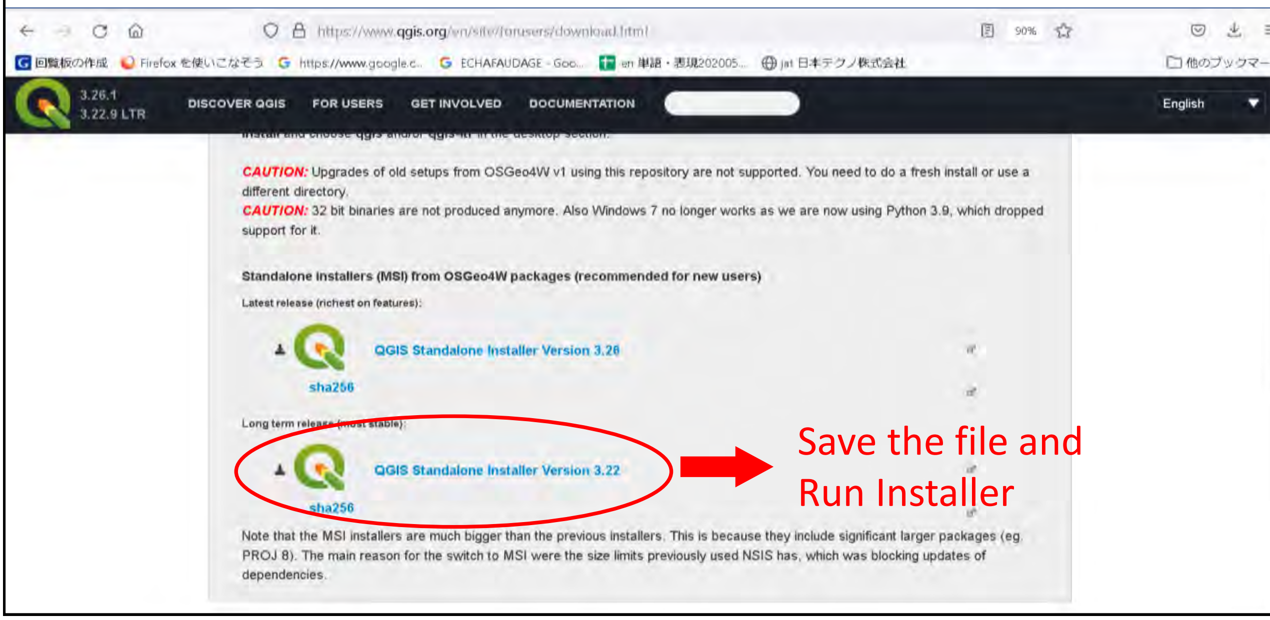
Geographic Information System GIS

A geographic information system (GIS) is a system that creates, manages, analyzes, and maps all types of data. GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what things are like there).

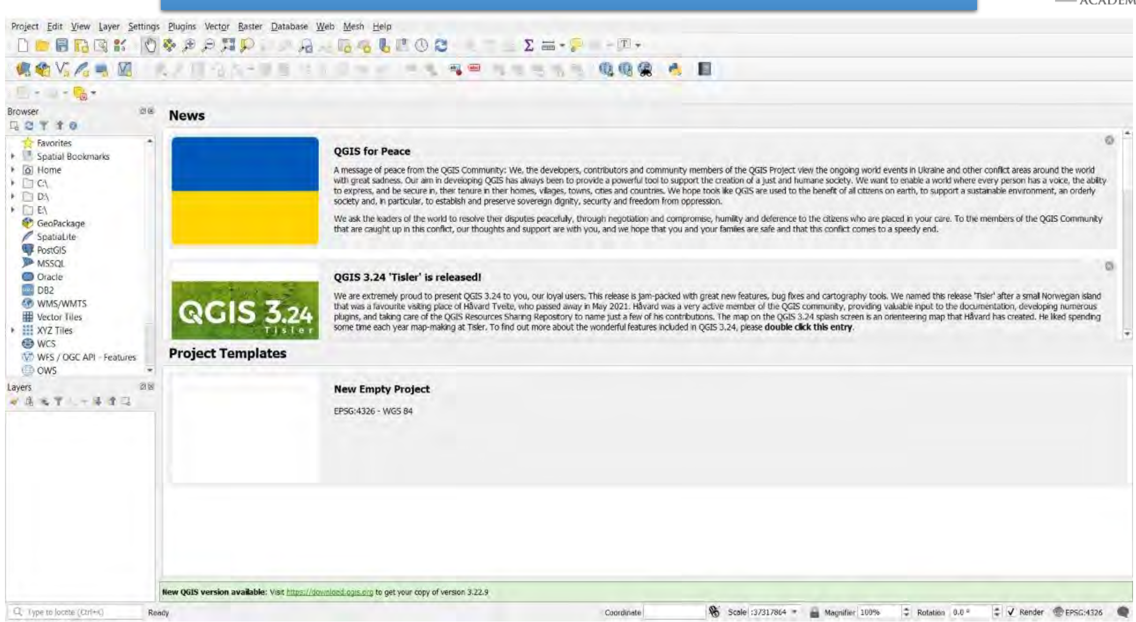
Types of Data Inputs in **GIS**

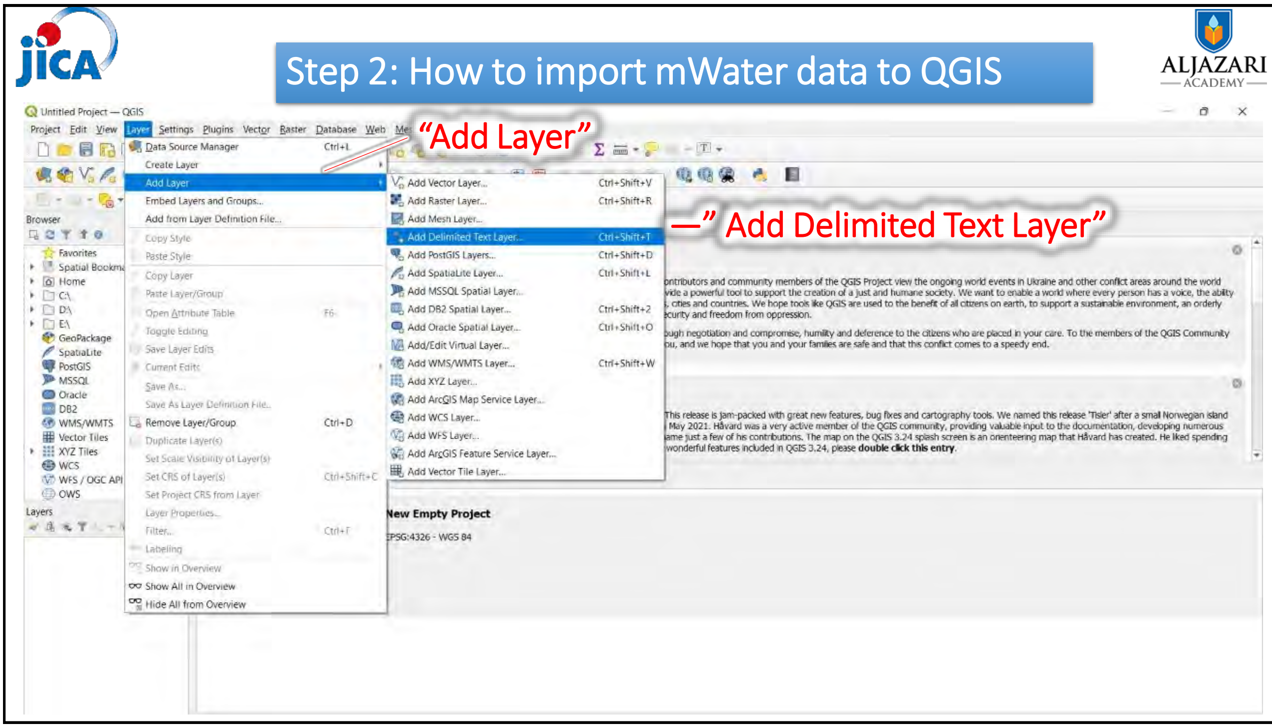
1. Vector Data
2. Raster data
3. Excel Data

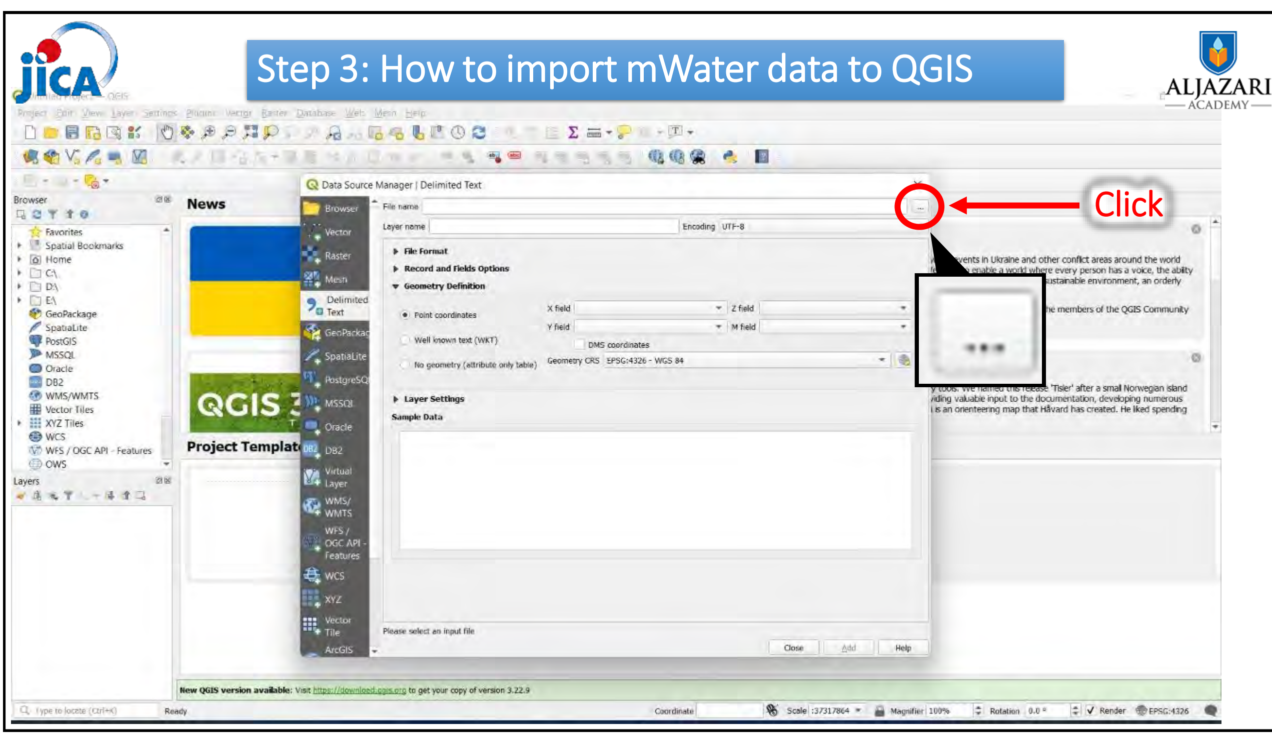
Step 2: How to install QGIS



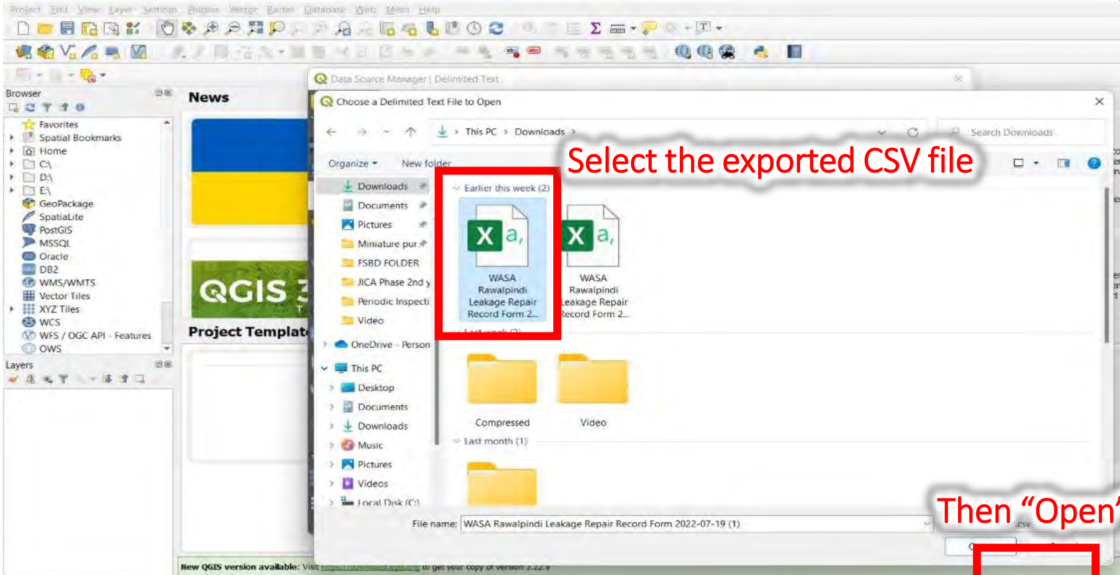
Step 1: How to import mWater data to QGIS



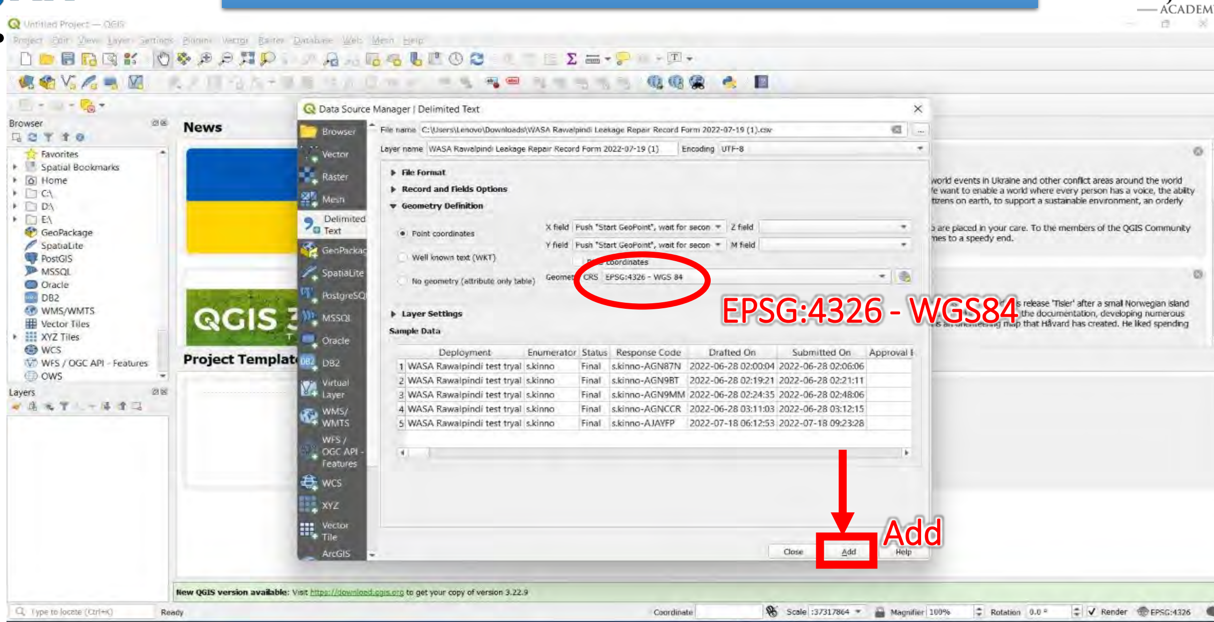

Step 2: How to import mWater data to QGIS
"Add Layer"
"Add Delimited Text Layer"
ALJAZARI
ACADEMY

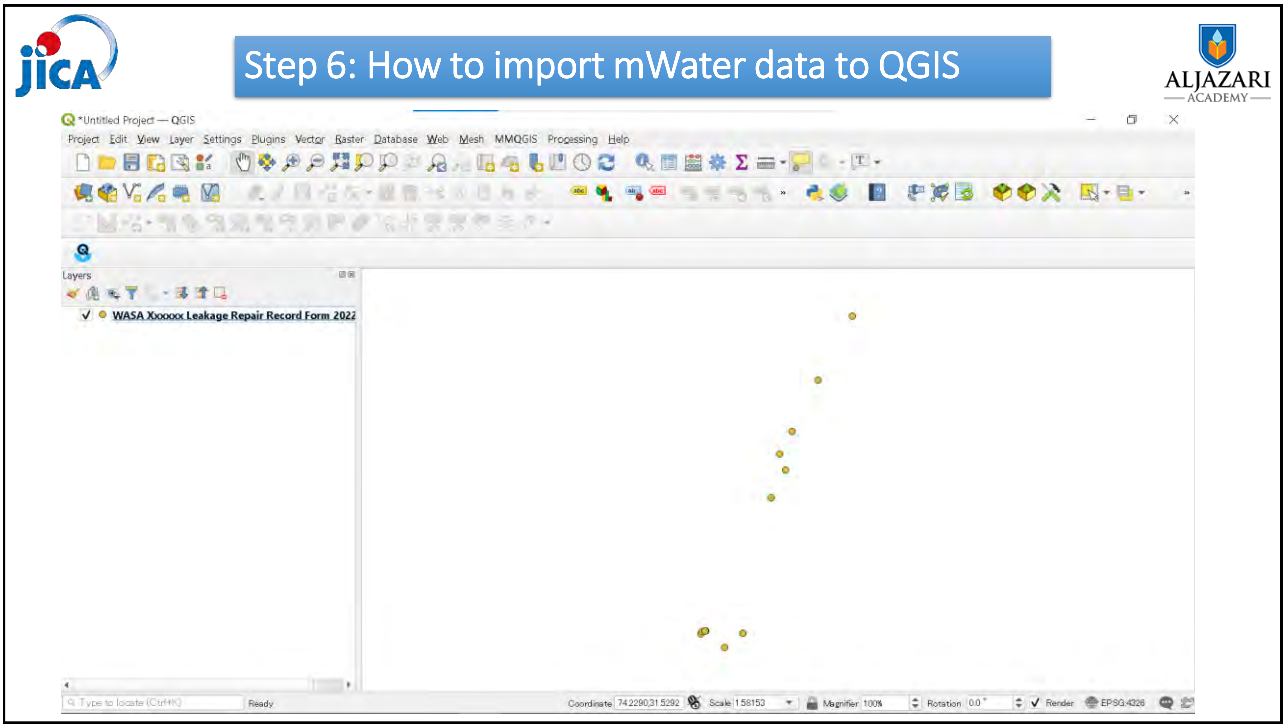

Step 3: How to import mWater data to QGIS
Click
Data Source Manager | Delimited Text
ALJAZARI
ACADEMY

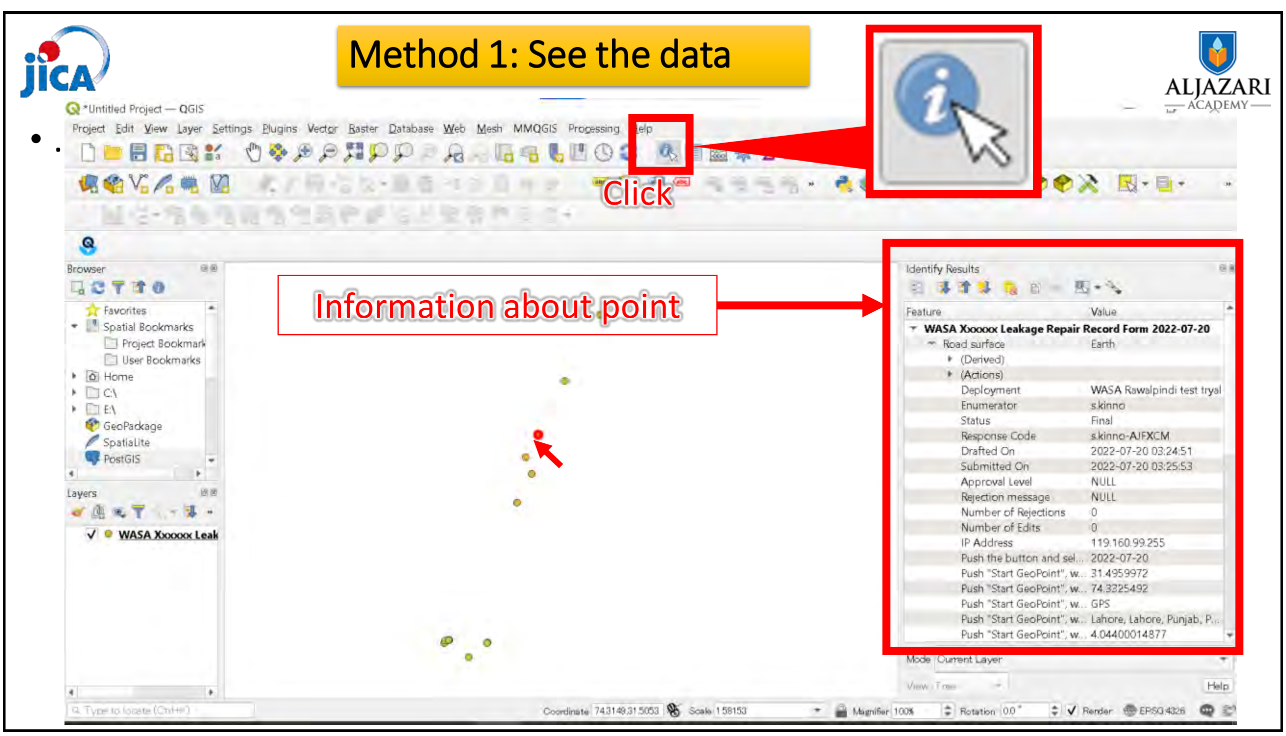
Step 4: How to import mWater data to QGIS



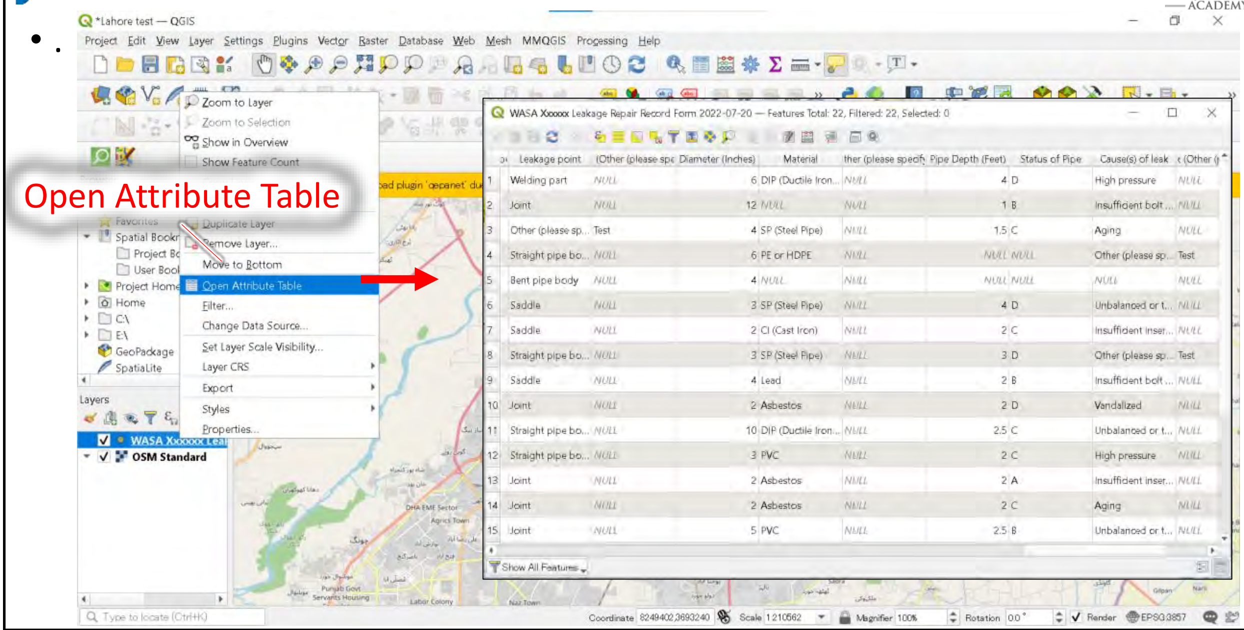
Step 5: How to import mWater data to QGIS



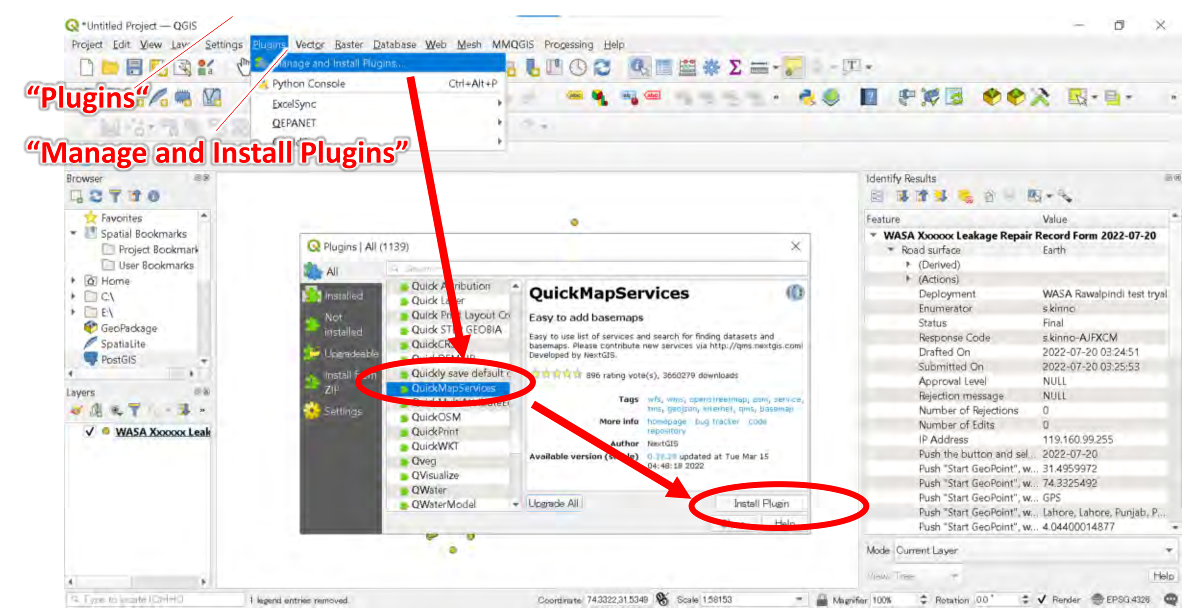

Step 6: How to import mWater data to QGIS
ALJAZARI
ACADEMY
*Untitled Project — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh MMQGIS Processing Help
Layers
WASA Xxxxxx Leakage Repair Record Form 2022
Ready
Coordinate 74.2290,31.5292
Scale 1:58153
Magnifier 100%
Rotation 0.0 °
Render
EPSG:4326


Method 1: See the data
ALJAZARI
ACADEMY
*Untitled Project — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh MMQGIS Processing Help
Click
Information about point
Browser
Favorites
Spatial Bookmarks
Project Bookmarks
User Bookmarks
Home
C:\
E:\
GeoPackage
SpatiaLite
PostGIS
Layers
WASA Xxxxxx Leak
Identify Results
Feature
Value
WASA Xxxxxx Leakage Repair Record Form 2022-07-20
Road surface
Earth
(Derived)
(Actions)
Deployment
WASA Rawalpindi test tryal
Enumerator
s.kinno
Status
Final
Response Code
s.kinno-AJFXCM
Drafted On
2022-07-20 03:24:51
Submitted On
2022-07-20 03:25:53
Approval Level
NULL
Rejection message
NULL
Number of Rejections
0
Number of Edits
0
IP Address
119.160.99.255
Push the button and sel...
2022-07-20
Push "Start GeoPoint", w...
31.4959972
Push "Start GeoPoint", w...
74.3225492
Push "Start GeoPoint", w...
GPS
Push "Start GeoPoint", w...
Lahore, Lahore, Punjab, P...
Push "Start GeoPoint", w...
4.04400014877
Mode
Current Layer
Help
Coordinate 74.3149,31.5053
Scale 1:58153
Magnifier 100%
Rotation 0.0 °
Render
EPSG:4326

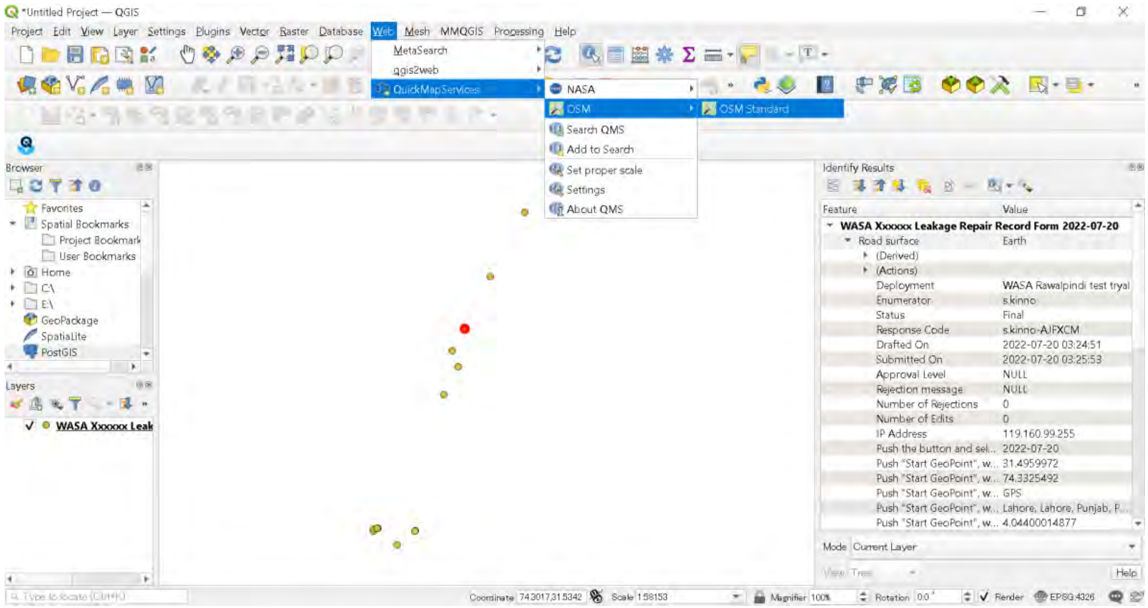
Method 2: See the data



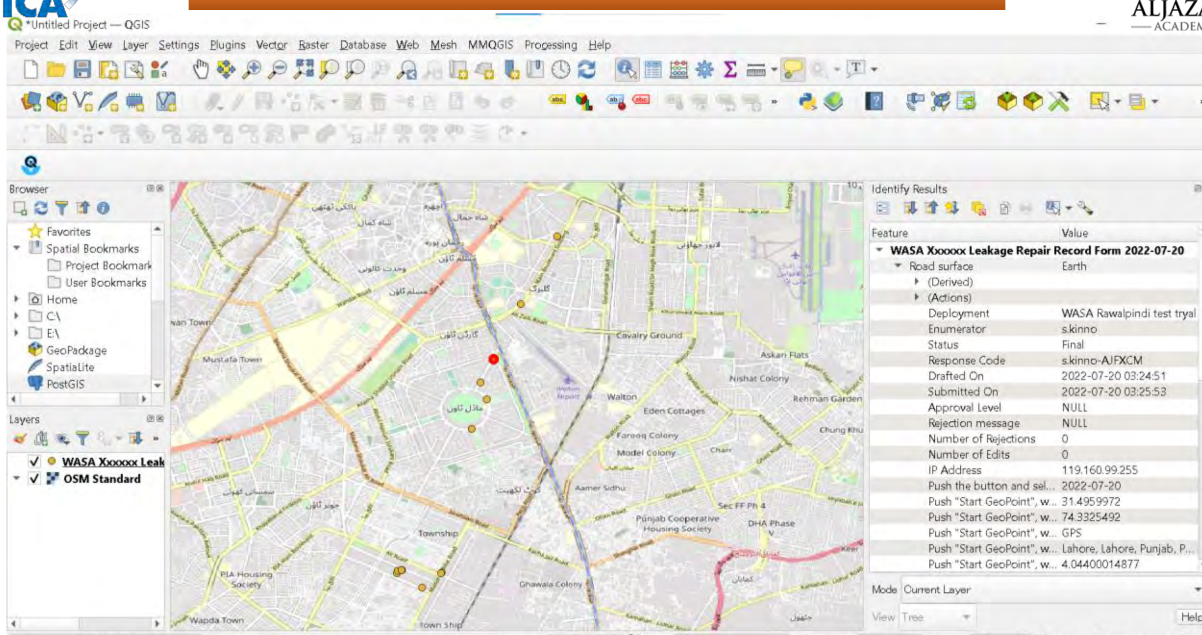
Step 1: How to show Background Map



Step 2: How to show Background Map



Step 3: How to show Background Map



Take full advantage of the data

Visualization in mWater Portal

- Quick check of the data

Excel

- Integrate and conserve all the data, calculate and analyze etc..

QGIS

- Visualize data on map and express the parameter as you like
- Prioritize the area for budget allocation of pipe replacement etc.

→ Exhibit the leakage situation effectively

- Request budget from the Government
- Attract international fund

In the name of Allah, the most Gracious and ever Merciful

Welcome To All Stakeholders

Course Team

Ms. Rebia Suhail	Course Lead
Mr. Syed Fahad Hussain	Module Lead
Mr. Wajih	JICA Coordinator
Mr. K Kayanoma	JICA Expert

WATER METER

1 Purpose
2 Knowledge acquisition
2.1 Meter reading
2.2 Type of meter
3 Metrology, Meter classes and other requirements
3.1 Definition of meter accuracy
3.2 Meter error curve
4 Meter maintenance

PURPOSE

Purpose of training

Understand meter reading, Type of meters, meter accuracy & class, maintenance.

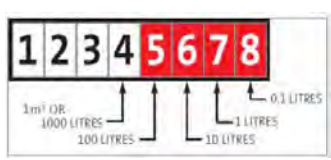
METER READING

The water meter shows several digits as shown in the figure. This digit means 1234 m3 and 567.8 liter, or 1234.5678 m3. When the counter of 0.1 liters is moving between two numbers, it is counted as lower number.

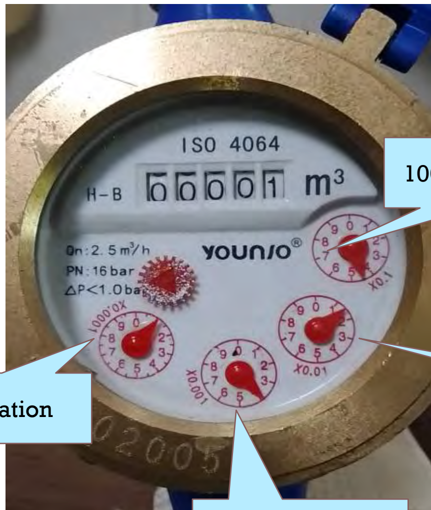
m3 is shown in the upper black digits and liter is shown in the lower red pointer. When the pointer is between two numbers, it is counted as lower number.

When the digit of counter reached maximum (e.g. 9999.999), it back to all zero (e.g. 0000.000), and sometimes it makes mistakes of calculation of consumption. As shown below, it is necessary to calculate on the assumption that it has one digit in the left side which is not shown on the display.

JIS : Japanese Industrial Standards（JIS B 8570-1:2013）

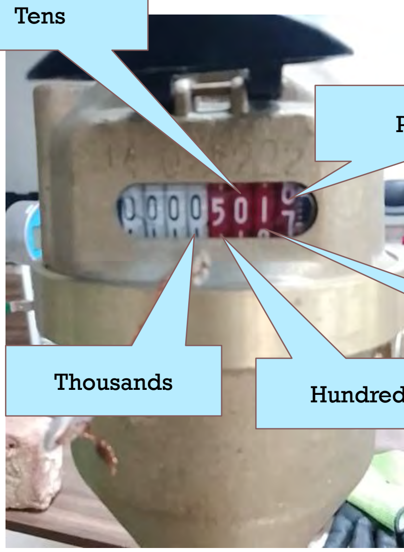


DISPLAY OF WATER METER



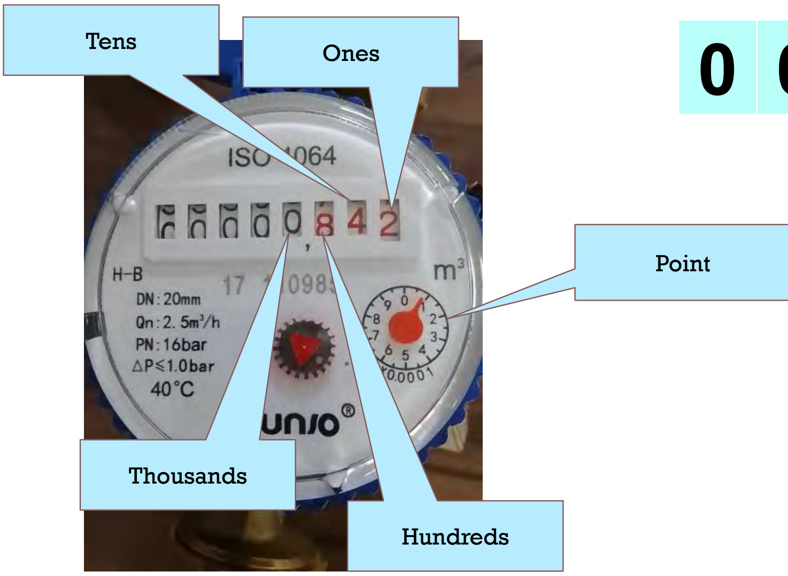
0 0 1 4 1 4.1

DISPLAY OF WATER METER



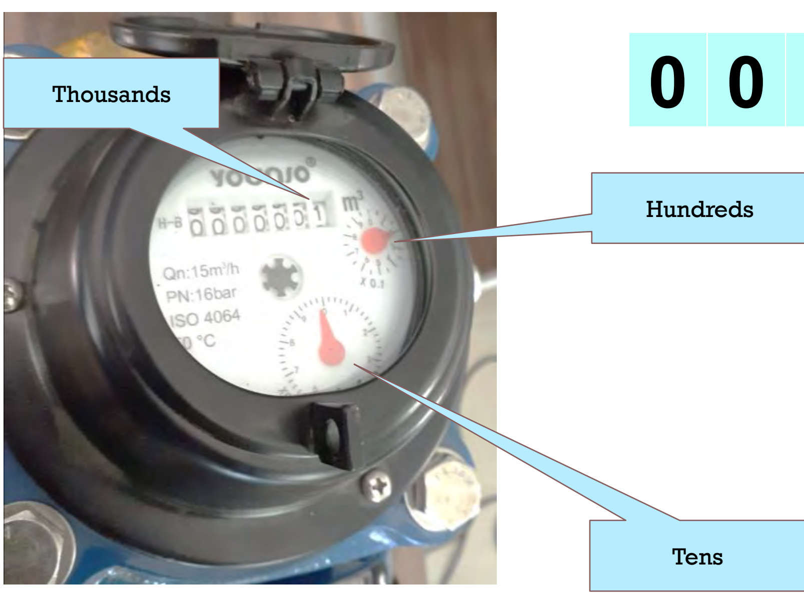
0 0 0 5 0 1.7

DISPLAY OF WATER METER



0	0	0	8	4	2.	1

DISPLAY OF BULK METER



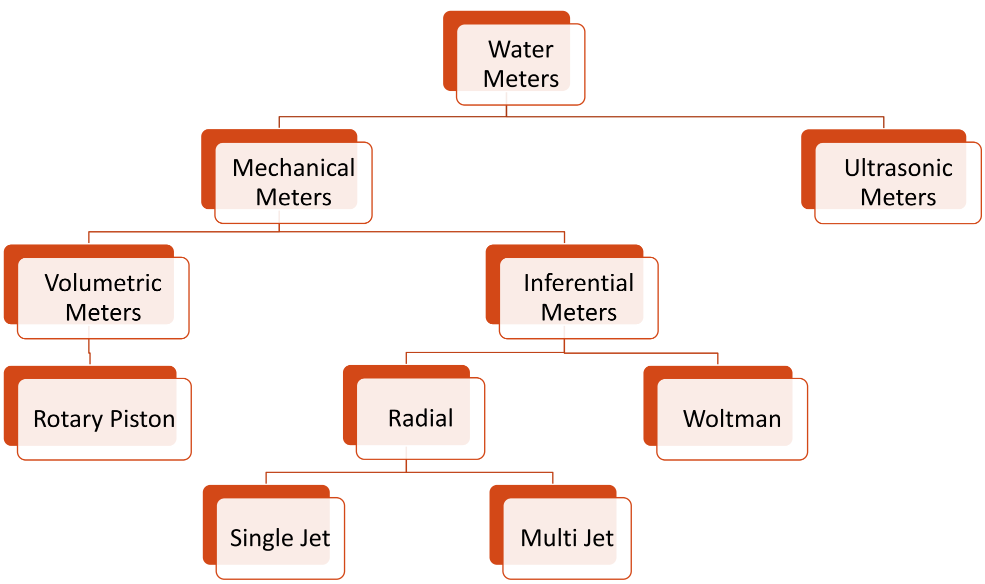
0	0	0	1	1	9	8

METER READING

	1	2	Difference (2-1)	3	4	Difference (4-3)
Bulk Meter						
R M 1						
R M 2						
R M 3						
R M 4						
Total RM						
L M 1						
L M 2						
L M 3						
L M 4						
Total LM						

TYPE OF METER

THE TYPE OF WATER METER IS CLASSIFIED AS BELOW.



WOLTMAN METERS

<Mechanism>

The Woltman meters are an inferential meter that uses an impeller with helical vanes. As water flows over the helical vanes, it rotates the impeller. Then, the rotation is transmitted to the dial via reduction gearing.

There are two main types of Woltmann meters called Horizontal (WP) and Vertical (WS) Woltmann meters. Horizontal Woltmann meters have their inlets and outlets directly along the pipeline. The axle of the helical vane is parallel to the flow.

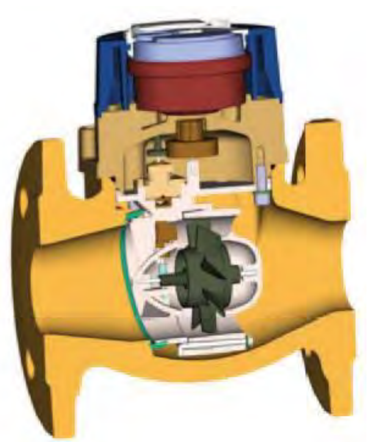
Water flows directly through the meter with small loss caused by the meter body.

The flow direction is changed 90 degrees after entering a vertical Woltmann meter, pass through the impeller and then turn back to the original direction as shown in the cross section of left Figure.

Woltmann meters have dry and sealed dials.

➢ Advantages: No power required, Highly accurate

➢ Disadvantages: If a foreign substance gets in, accuracy falls, or the impeller will be damaged. Piping friction loss occurs. Not applicable to large diameter pipes.



APPLICATION AND INSTALLATION

Woltmann meters are widely used throughout the world. They are mainly used to measure the consumption volume of bulk users, or to determine the flow pattern in water distribution systems. Horizontal Woltmann meters can be installed in all directions without affecting the accuracy. The counter, however, should never be placed upside down. Vertical Woltmann meters must be installed horizontally with the display facing upwards.

➢ Applicable pipe diameter: 40mm – 400mm

➢ Suitable installation location: Place where the power is out and there is no cover to protect rainwater

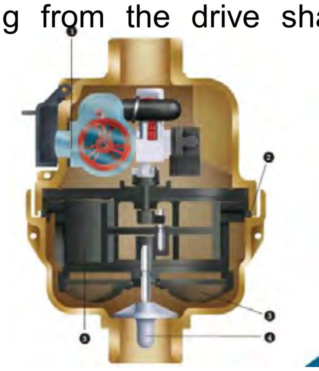
ROTARY PISTON METERS

Rotary piston meters are popular for their combination of accuracy, long life and moderate cost so they are widely used. Rotary piston meters come in many different shapes and sizes as shown. Wet or dry dials are used. Sand or other suspended solids easily get stuck between the piston and chamber wall. Thus, it is important to be installed in the system with very good water quality and to install built-in strainer.

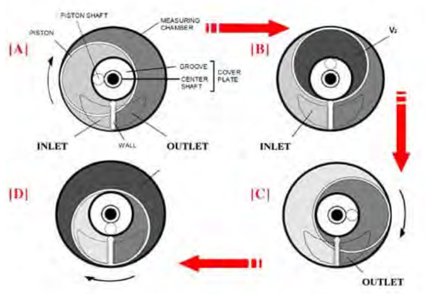
<MECHANISM>

The piston and cylinder are alternately filled and emptied by the fluid passing through the meter. A slot in the sidewall of the piston is removed so that a partition extending inward from the bore of the working chamber can be inserted. This has the effect of restricting the movement of the piston to a sliding motion along the partition. The rotary movement of the piston is transmitted via a permanent-magnet coupling from the drive shaft to a mechanical register.

1. Easy to read register
2. ”O” ring seal
3. Stainer
4. Non-Return valve
5. Piston and cylinder



Application and Installation



Rotary piston meters are commonly used most domestic applications up to diameter 25mm. They are not sensitive to the wide flow velocity profile.

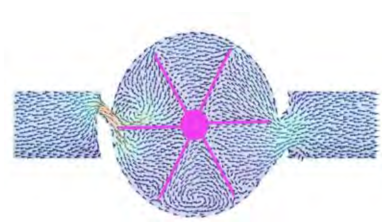
Rotary piston meters can be installed in **any position** with stable accuracy and placed close to bend or pump.

➢ Applicable pipe diameter: 13mm – 40mm

➢ Suitable installation location: Place where the power is out and there is no cover to protect rainwater

SINGLE JET METERS

- Single-jet meters are a low-cost option because there's a direct impact to the impeller by the water flow
- The water is channeled through a single jet over a impeller placed inside the body of the meter. Impeller circulating the flowrate.
- Resistant to suspended solids.
- Small and can be installed in tight spaces.
- Most single jet meters have to be installed perfectly horizontally and upright to ensure accurate measurements



MULTIPLE JET METERS

<Mechanism>

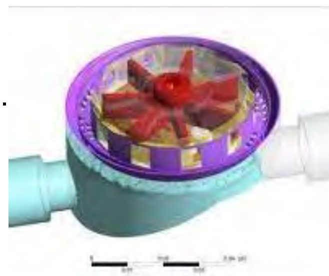
The multi jet meters are an inferential water meter. Their operation is similar to that of single jet meter, except that they use several jets to drive the impeller at multiple points.

This means that the forces on the impeller are better balanced than in single jet meters, which reduces wear on the moving parts and provides greater durability. A cutaway view of a multi jet meter is shown in the left photo.

Multi jet meters normally use an internal bypass with a regulating screw to adjust the flow passing through the impeller. This allows the manufacturer to adjust the meter's error curve for achieving the best accuracy before sealing it for the prevention of meter tampering. A strainer is installed on the inlet side, which can be removed for cleaning.

➢ Advantages: No power required, Accurate at low flow rate

➢ Disadvantages: If a foreign substance gets in, accuracy falls, or the impeller will be damaged. Piping friction loss occurs. Not applicable to large diameter pipes.

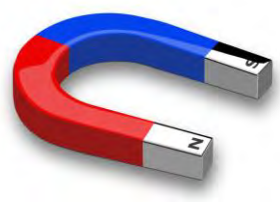


COMPARISON OF WATER METERS

	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

METER TAMPERING

Unauthorized manipulation of the water meter for the purpose of stealing water. The offense also includes placing magnets, placing foreign objects inside the meter inverting the position of the meter, breaking water meters: all for the purpose of slowing down the meter registry eventually lessen water consumption




3 METROLOGY, METER CLASSES AND OTHER REQUIREMENTS

3.1 DEFINITION OF METER ACCURACY

The volume of water that passes through a water meter is called the actual volume, or Va. However, since no meter is 100% accurate, the meter will not register all the water passing through it but show a indicated volume (Vi), which is slightly lower or higher than the actual volume. The difference between the indicated volume and actual volume (Vi - Va) is called the meter error. When the error is expressed as a fraction (percentage) of the actual volume, it is called as the relative error.

[Relative error]: (Vi - Va) / Va x 100 (%)

Where: Vi is the indicated volume. Va is the actual volume.

3.1 DEFINITION OF METER ACCURACY

CALCULATION OF THE ERROR (%)

$$\text{Error (\%)} = \frac{\text{Indicated Volume (meter reading result)} - \text{Actual Volume}}{\text{Actual Water Volume}} \times 100$$

METER ERROR CURVE

- Q1 – Minimum flow rate:

The lowest flow rate at which the meter is required to give indications within the maximum permissible error tolerance (± 5% error).

- Q2– Transitional flow rate:

The flow rate at which the maximum permissible error of the water changes in value from ± 5% error to ± 2% error.

- Q3 – Permanent flow rate:

Permissible continuous load. Half the maximum flow rate (± 2% error).

- Q4 – Maximum flow rate (Overload Flow Rate):

The highest flow rate at which the meter is required to operate in a satisfactory manner for a short period without deteriorating (± 2% error)

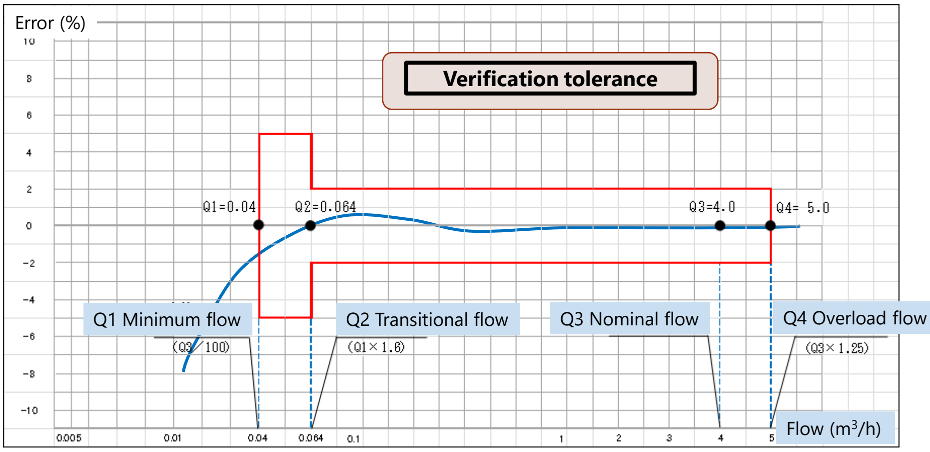
METER ERROR CURVE

Water meters are designed for a specific flow rate, which is called as the permanent flow rate or Q3.The meter should be able to work at the permanent flow rate (or a lower flow rate) continuously for its design life without exceeding the permissible error.

Although a meter is designed for the permanent flow rate, the actual flow through a meter is not constant. Thus, water meters should not only be accurate at the permanent flow rate, but also be accurate over a wide range of flow rates.

It is useful to draw a graph of a meter's relative error. This curve is called the meter's error curve.

3.2 METER ERROR CURVE



MAINTENANCE

The proper maintenance of any metering device is essential to ensure the accuracy. Most meter manufacturers have a recommended maintenance and testing method in the operation manual.

The most common problems experienced with water meters in the field are as below:

➢ Suspended solids in the water cause stuck or damage of meter and meter strainer. These solids enter the system most often due to:

- Large pipe bursts.
- Inadequate flushing of pipes after installations or repairs.
- High velocities in the network stir up sediments that was accumulated on the bottom of pipes.
- Inadequate water treatment or malfunction of treatment plants.

A strainer should be installed upstream of the meter to protect the rotor from objects such as stones and pebbles. As for maintenance, the strainer needs to be cleaned regularly.

SERVICE PIPE

SERVICE PIPE

1 Purpose of training
2 Knowledge acquisition
2.1 Outline of PPR pipe
3 Jointing method
3.1 Socket fusion joint
3.2 Thread joint
4 Practice

1 PURPOSE OF TRAINING

The purpose of this training is to provide a practical training on installation of PPR service pipes. Also, it is important to share the knowledge of this training with not only the staff of WASA but also contractors.

2 KNOWLEDGE ACQUISITION

2.1 Outline of PPR

➢ Standard of PPR pipes

 ISO 15874 standard green PPR pipe, DIN 8077-8078 hot water PPR pipe.

PPR pipes & fittings Characteristics:

1. Well heart resistance ability
   The pipes can be used for a long time while the working temperature of water is 70℃
2. Well insulation ability
3. Long lifetime span
   Under normal conditions of temperature and pressure PPR pipe can be over 50 years.
4. Little resistance for water flow
   The inner walls of PPR pipes are smooth and limescale will not be formed there
5. Economical
6. Light weight
7. Well corrosion resistance

3 JOINTING METHOD

There are mainly two jointing method for PPR distribution pipes: Socket fusion joint and Thread joint.

3.1 Socket fusion joint

Socket fusion joint Details

Socket fusion joint connect PPR pipe and socket by heat of socket fusion welding machine. This method is very common way to joint PPR service pipe and the durability of this joint part is high.

3.2 Thread joint

Thread joint Details

Male thread and female thread are used for thread joint. The thread has shape of screw and male thread and female thread can be connected very easily and swiftly.

4 PRACTICE

【Preparation Item】

- Socket fusion welding machine
- Scale
- Elbow
- PPR pipe
- Pipe cutter

STEPS PROCEDURES

1. Check the pipe and socket whether they are damaged or not.
2. Measure the depth of socket and mark the insertion length on the pipe surface.
3. Cut the pipe at right angles by using a pipe cutter.
4. Always ensure that the welding machine corresponds to the required jointing size.
5. Required operating temperature of the welding machine is 250℃-270℃
6. Push the end of the pipe and socket into socket fusion welding machine up to the marked insertion length. Be careful not to turn the pipe and socket while heating.
7. Pull out the pipe and socket from the socket fusion welding machine after proper heating time, insert the pipe into socket evenly and swiftly and wait until they cool down.

STEPS PROCEDURES

Outside Diameter	Average Heating Time*	Average Working Time (max.)	Average Cooling Time (min.)
mm	sec	sec	min
20	5	4	2
25	7	4	2
32	8	6	4
40	12	6	4
50	18	6	4
63	24	8	6
75	30	8	6
90	40	8	6
110	50	10	8

Name:	**Dept:**	**Designation:**

1. HDPE Pipe

High density polyethylene (HDPE) piping systems have been used for municipal and industrial water applications. HDPE water pipes are made of high-density polyethylene, which is a thermoplastic polymer. Polyethylene has a number of significant advantages over traditional materials such as steel or ductile iron including lower weight, freedom from corrosion and the ability to coil long lengths of pipe.

a. Salient Features of HDPE Pipes

- Safe for drinking water with no toxic or chemical contamination.
- High flexibility. Can be bent as much as 25-40 times of the pipe diameters. Thus, reducing unnecessary pipe joint.
- Light weight with only 0.95 grams/cm2. It weighs only 1/5 of steel pipes of the same size.
- Rust proof and high resistance to damaged chemicals, making the product last up to 50 years.
- Super smooth internal surface, reducing the chance of pipe cloggage.

b. PE80 vs PE100 Comparison

Comparison of PE 100 and PE 80 HDPE Pipes
▪ Before international standards were adopted polyethylene (PE) materials were commonly named by their density - low density, medium density and high density. ISO standards were further developed to designate materials as PE80 or PE100 to easier differentiate the benefits of the materials. ▪ PE80 pipes are often rated SDR11 PN12 and have a minimum required strength (MRS) of 8 MPa (Megapascal) whereas PE100 pipes are rated SDR11 PN16 and have a MRS of 10 Mpa. ▪ PE100 offers additional long-term strength and performance over PE80 while allowing for thinner pipe walls for the same operating pressure.

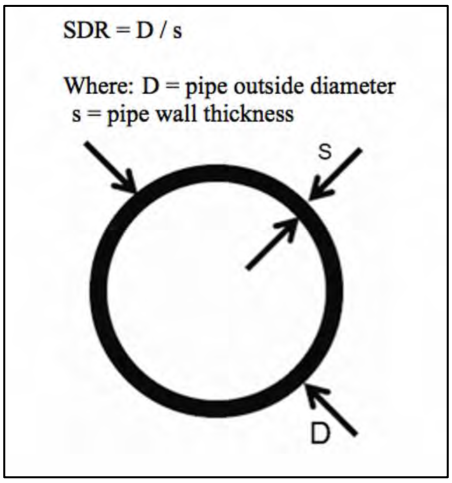
c. HDPE pipes color code guide:

Red	Electric power lines, cable, conduit and lighting cables
Orange	Telecommunication, alarm or signal lines, cables or conduit
Yellow	Fuel gas (methane or propane), oil, petroleum, steam or gaseous materials
Green	Sewers and drain lines
Blue	Potable water
Violet (Purple)	Reclaimed water, irrigation and slurry lines

Name:	Dept:	Designation:

2. HDPE Pipe Parameters

a. Standard Dimension Ratio (SDR)



Standard dimension ratio (SDR) is a method of rating a pipe's durability against pressure.

SDR= D/s

Where;

D= Outside diameter of pipe

S= Thickness of pipe

It’s an inverse relationship. The higher the SDR, the lower the pressure rating.

b. In HDPE Pipe terms, MRS stands for “Minimum Required Strength” (MRS).

The MRS is determined by performing regression analysis in accordance with ISO 9080 on the test data from the results of long-term pressure testing.

Material Designation	Minimum Required Strength (MRS)MPa
PE100	10.0
PE80	8.0

Another parameter is defined as the ‘Maximum Operating Pressure' MOP, or the pressure rating of the pipe.

MOP = 2 x MRS / C (SDR - 1) ---- Where MRS and MOP are in MPa

MOP = 20 x MRS / C (SDR - 1) ----- Where MRS is in MPa and MOP is in bar.

Where C is the ‘overall service (design) coefficient, or Safety Factor.

For water applications the minimum value of C is 1.25

Name:	Dept:	Designation:

c. Pressure Reduction Factor

Table 1 — Pressure reduction factors for temperatures between 20 °C and 50 °C

Material classification	Pressure reduction factors[a b]						
	20 °C	25 °C	30 °C	35 °C	40 °C	45 °C	50 °C
PE 100 PE 80	1,00	0,92	0,85	0,79	0,73	0,67	0,63
PE 63	1,00	0,92	0,85	0,79	0,73		
PE 40	1,00	0,92	0,85	0,77	0,70		

[a] Reference to ISO 9080:2012 shall be made for extrapolation time limits, see 5.3.

[b] The ISO 9080:2012 extrapolation factors are 50 for 40 °C, 30 for 45 °C and 18 for 50 °C when the material is tested at a maximum temperature of 80 °C. If the material is tested at a higher temperature than 80 °C then other extrapolation factors may apply.

3. Available Sizes of PE 100 pipes

Dimension Ratio	SDR21	SDR17	SDR 13.6	SDR11
	PN8	PN10	PN 12.5	PN16
OUTSIDE DIAMETER (mm)	Wall Thickness (mm)	Wall Thickness (mm)	Wall Thickness (mm)	Wall Thickness (mm)
20	-	-		2.0
25	-	-	2.0	2.3
32	-	2.0	2.4	3.0
40	2.0	2.4	3.0	3.7
50	2.4	3.0	3.7	4.6
63	3.0	3.8	4.7	5.8
75	3.6	4.5	5.6	6.8
90	4.3	5.4	6.7	8.2
110	5.3	6.6	8.1	10.0
125	6.0	7.4	9.2	11.4
140	6.7	8.3	10.3	12.7
160	7.7	9.5	11.8	14.6
180	8.6	10.7	13.3	16.4
200	9.6	11.9	14.7	18.2
225	10.8	13.4	16.6	20.5
250	11.9	14.8	18.1	22.7
280	13.4	16.6	20.6	25.4
315	15.0	18.7	23.2	28.6
355	16.9	21.1	26.1	32.2
400	19.1	23.7	29.4	36.3
450	21.5	26.7	33.1	40.9

Name:	**Dept:**	**Designation:**

HDPE Pipe Parameters – Class Activity 1

Diameter (mm)	Thickness (mm)	SDR	MOP (bar)	Avg. Temperature in your area	Temperature Factor (From table 1)	Effective MOP (bar)

	Unit	Labour	Composite	Unit	Labour	Composite
c) PN-10 (SDR-17)						
i) 90 mm	P.Rft	4.60	240.85	PM	12.55	790.25
ii) 110 mm	P.Rft	12.85	364.65	PM	35.10	1,196.45
iii) 125 mm	P.Rft	14.20	463.00	PM	38.80	1,519.05
iv) 160 mm	P.Rft	15.60	752.25	PM	42.65	2,468.20
v) 180 mm	P.Rft	20.00	951.85	PM	54.70	3,122.95
vi) 200 mm	P.Rft	22.35	1,172.85	PM	61.10	3,848.15
vii) 225 mm	P.Rft	25.50	1,486.00	PM	69.70	4,875.65
viii) 250 mm	P.Rft	35.20	1,824.55	PM	96.30	5,986.40
ix) 315 mm	P.Rft	62.45	2,904.80	PM	170.70	9,530.70
x) 355 mm	P.Rft	69.45	3,688.60	PM	189.85	12,102.25
xi) 400 mm	P.Rft	78.60	4,654.90	PM	214.95	15,272.70
xii) 450 mm	P.Rft	79.85	5,888.40	PM	218.40	19,319.85
xiii) 500 mm	P.Rft	94.05	7,281.95	PM	257.10	23,892.05
xiv) 560 mm	P.Rft	104.40	9,138.50	PM	285.40	29,983.35
xv) 630 mm	P.Rft	117.10	11,537.95	PM	320.15	37,856.00
xvi) 710 mm	P.Rft	132.65	14,684.75	PM	362.65	48,180.60
xvii) 800 mm	P.Rft	150.45	18,566.10	PM	411.30	60,915.35
xviii) 900 mm	P.Rft	189.25	23,593.55	PM	517.45	77,410.35
xix) 1000 mm	P.Rft	219.70	29,119.95	PM	600.70	95,542.55

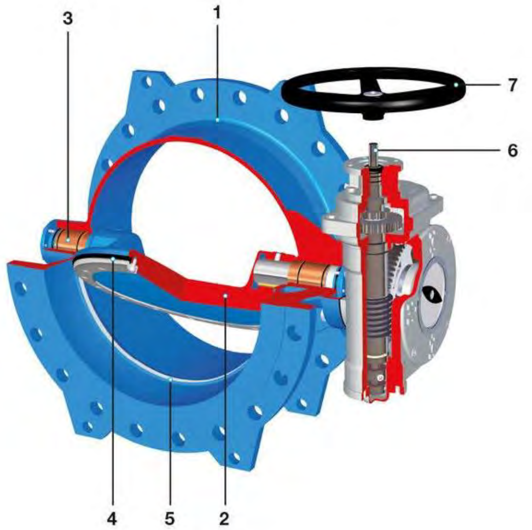
PN Rating	Diameter	Length	Unit Cost (Composite-Labour)	Total Cost
PN 10		**100 ft**		

Name:	Dept:	Designation:

Valves – Class Activity 2

i. Label the picture displayed below according to the numbers:

No.	Labelling
1	
2	
3	
4	
5	
6	



ii. Choose the correct answers.

a) Non-return valve or check valve is used for?

( ) To reverse the flow ( ) To prevent reverse flow ( ) To stop the flow

b) Which type of valve is recommended to use for isolation?

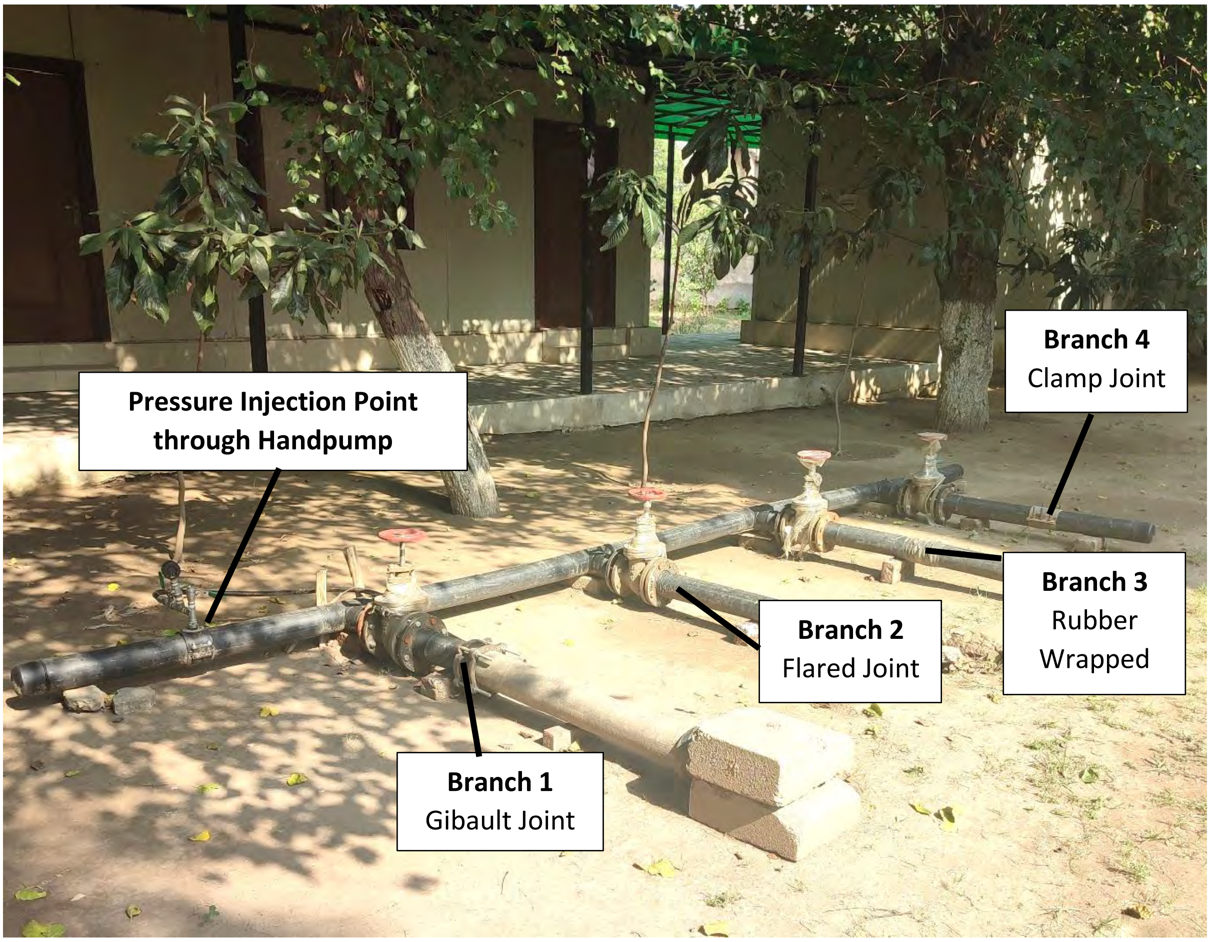
( ) Sluice/gate valve ( ) Butterfly valve ( ) Air release valve

c) Air release valve are used for?

( ) To release entrapped air ( ) To pump air ( ) Both

Name:	Dept:	Designation:

4. Hydrostatic Pressure Test Activity for HDPE Pipe



Instructions:

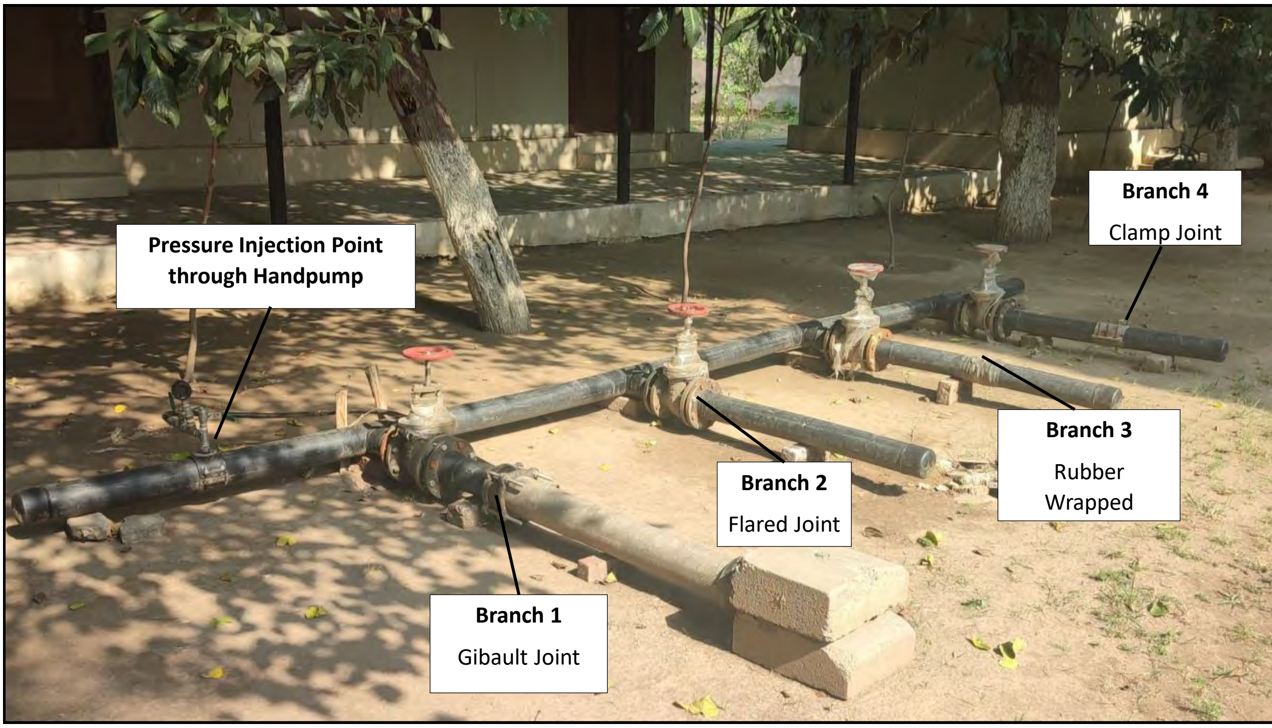
- Setting the Optimum Pressure for Test: Working pressure of Pipe x 1.5
- Time Duration: 10 mins (2 hours as recommended in the standard)
- Hazard Awareness: Participants are advised to keep a distance from potential leakage joint or valve
- Fill the pipe with water by connecting to the nearby source until water come out on the other end. For the releasing air, we can use air valve.
- Pressurizing: Inject the water with the help of hand pump to build a pressure inside pipes up to desired pressure rating.
- Observe the joints and valves for leakages. If any leakage appears, note the reading on pressure gauge.
- Keep pressuring branch wise until setting pressure and close valve, Start counting time.
- If no leakage appears after holding the optimum pressure for specified time, the joint is considered valid.

Name:	**Dept:**	**Designation:**

Hydrostatic Pressure Testing – Class Activity 3

Participants to perform the pressure test activity and observe the leakages and corresponding pressure ratings.

Leakage Point	Pressure	Reliability (Low, Medium, High)
Branch 1 – Gibault Joint		
Branch 2 – Flared Joint		
Branch 3 – Rubber Tube		
Branch 4 – Clamp Joint		


Pressure Injection Point through Handpump
Branch 4
Clamp Joint
Branch 3
Rubber Wrapped
Branch 2
Flared Joint
Branch 1
Gibault Joint

Annex 5.1.49 Training Material for "O&M of Mechanical and Electrical Equipment" in Fall (November) 2022

1. Introduction to Motor Control Unit:

(Demo Motor Control Unit)

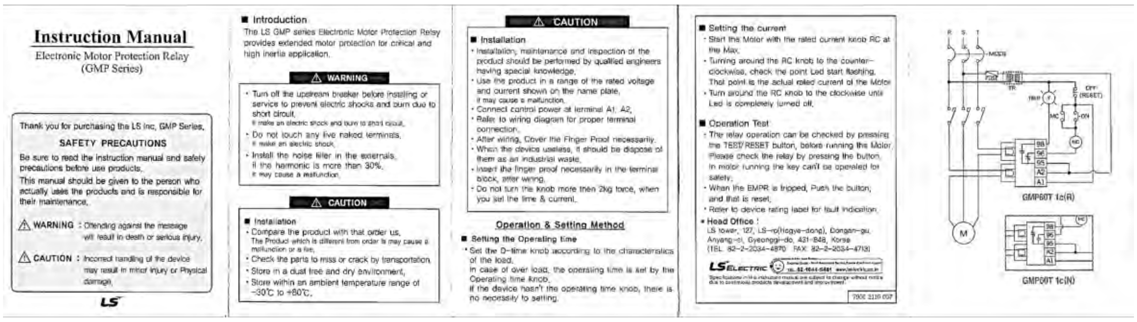
(DOL panel for miniature Pump Station)

2. Tools required for the activities:

3. Operation of each component of MCU:

Sr. No.	Name of Component	Quantity
1	Clamp meter	01
2	Voltage Detector	01
3	MCB	03
4	MCCB	01
5	Magnetic Contactor	03
6	Current Transformers	03
7	Ammeter	01
8	Selector Switch for Ammeter	01
9	Voltmeter	01
10	Selector Switch for Voltmeter	01
11	Push Button (ON)	01
12	Push Button (OFF)	01
13	Emergency Push Button	01
14	Lamps for status ON, OFF and Fault	03
15	Timer	01
16	Over/ Under Voltage Monitoring Relay	01
17	Electronic Over Current Protection Relay	01
18	Liquid Level Controller	01
19	Fuse	01
20	Connectors and Thimbles	-
21	Gloves	01

Electronic Over Current Protection Relay

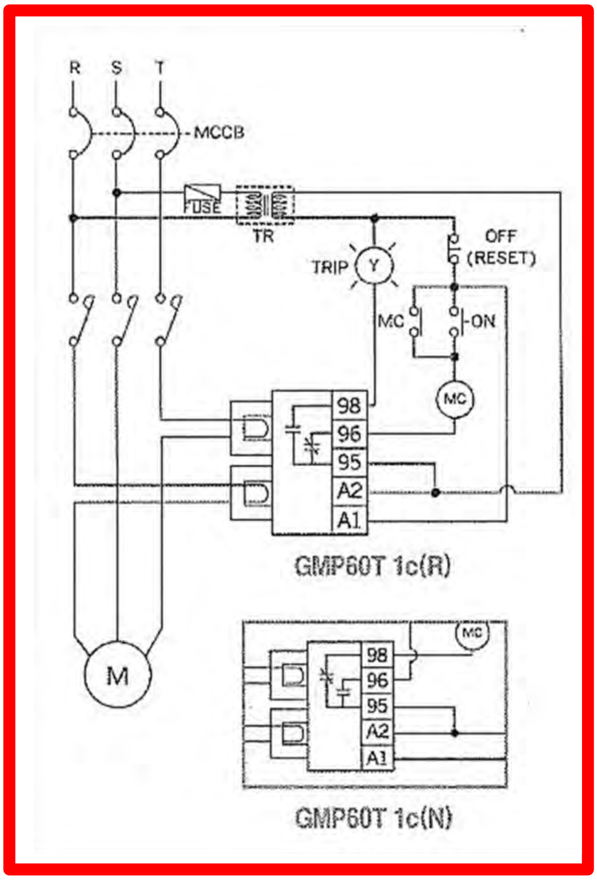


■ Setting the current

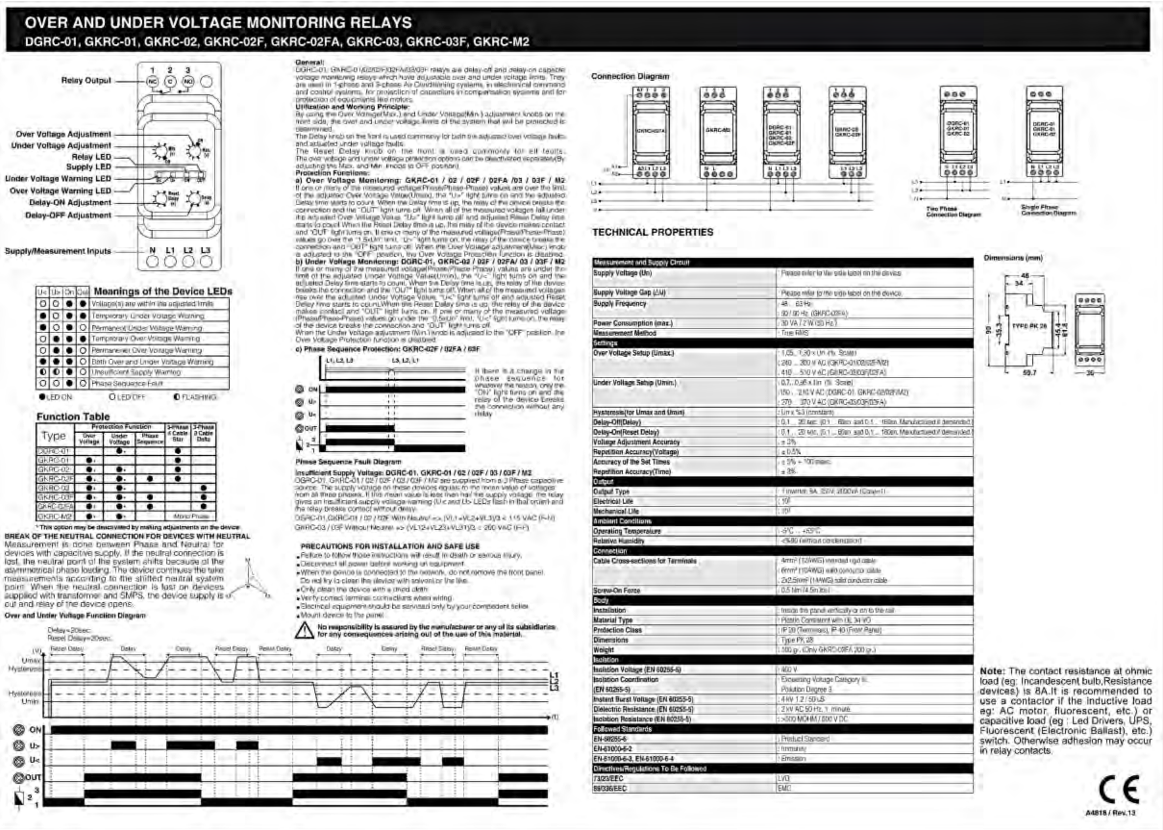
- Start the Motor with the rated current knob RC at the Max.
- Turning around the RC knob to the counter-clockwise, check the point Led start flashing. That point is the actual rated current of the Motor.
- Turn around the RC knob to the clockwise until Led is completely turned off.

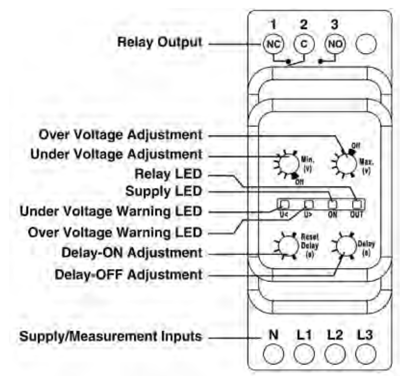
■ Operation Test

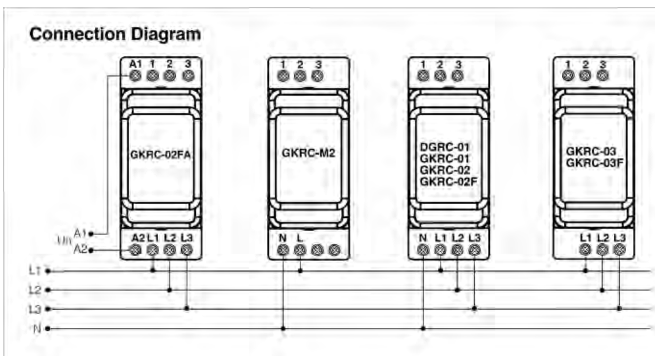
- The relay operation can be checked by pressing the TEST/RESET button, before running the Motor. Please check the relay by pressing the button. In motor running the key can't be operated for safety.
- When the EMPR is tripped, Push the button, and that is reset.
- Refer to device rating label for fault indication.



Over/ Under Voltage Monitoring Relay







Measurement and Supply Circuit	
Supply Voltage (Un)	: Please refer to the side label on the device.
Supply Voltage Gap (ΔU)	: Please refer to the side label on the device.
Supply Frequency	: 48 ... 63 Hz. : 50 / 60 Hz. (GKRC-02FA)
Power Consumption (max.)	: 30 VA / 2 W (50 Hz.)
Measurement Method	: True RMS
Settings	
Over Voltage Setup (Umax.)	: 1,05...1,30 x Un (% Scale) : 240 ... 300 V AC (GKRC-01/02/02F/M2) : 410 ... 510 V AC (GKRC-03/03F/02FA)
Under Voltage Setup (Umin.)	: 0,7...0,95 x Un (% Scale) : 150 ... 210 V AC (DGRC-01, GKRC-02/02F/M2) : 270 ... 370 V AC (GKRC-03/03F/02FA)
Hysteresis(for Umax and Umin)	: Un x %3 (constant)
Delay-Off(Delay)	: 0.1 ... 20 sec. (0.1 ... 60sn. and 0.1 ... 180sn. Manufactured if demanded.)
Delay-On(Reset Delay)	: 0.1 ... 20 sec. (0.1 ... 60sn. and 0.1 ... 180sn. Manufactured if demanded.)
Voltage Adjustment Accuracy	: ± 3%
Repetition Accuracy(Voltage)	: ± 0.5%
Accuracy of the Set Times	: ± 5% + 100 msec.
Repetition Accuracy(Time)	: ± 3%
Output	
Output Type	: 1 inverter, 8A, 250V, 2000VA (Cosφ=1)
Electrical Life	: 10^5
Mechanical Life	: 10^7

PRECAUTIONS FOR INSTALLATION AND SAFE USE

- Failure to follow those instructions will result in death or serious injury.
- Disconnect all power before working on equipment.
- When the device is connected to the network, do not remove the front panel. Do not try to clean the device with solvent or the like.
- Only clean the device with a dried cloth.
- Verify correct terminal connections when wiring.
- Electrical equipment should be serviced only by your compedent seller.
- Mount device to the panel

⚠ **No responsibility is assured by the manufacturer or any of its subsidiaries for any consequences arising out of the use of this material.**

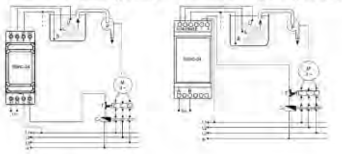
Liquid Level Controller

LIQUID LEVEL CONTROLLERS
SSRC-04

General

Liquid level controllers are commonly used for the level and discharge control of conductive liquids in tanks located in industrial plants and domestic applications.

Connection Diagram Type PK-28 **Connection Diagram Type PK-25**



Operation Principles

See above connection diagram

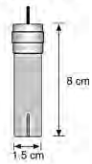
The output contact switches ON when the liquid reaches the upper level electrode(U). The output contact switches OFF when the lower level electrode (L) is no longer in contact with the liquid (in order to prevent the system to work with empty containers). B (Terminal 8) has to be connected to the container in order to determine the bottomlevel accurately. If the container is made of a non conductive material, an additional electrode connected to B (Terminal 8) must be used. R(kΩ) (i.e., impedance between electrodes) can be adjusted to 5-50 kΩ for different liquids by means of the knob on the front panel.

The Out LED on the front panel lights when the relay is ON position.
Note: This controller can not be used with flammable liquids.

Technical Data

Operating Range (ΔU)	:Please look at labels on the device. : 190-260 V AC : 340-460 V AC
Rated Frequency (f)	: 50/60 Hz
Output Contacts	: 1 C/O, 8A, 2000 VA, Cosφ=1
Sensitivity (R(kΩ))	: Adjustable 5 - 50 kΩ
Warning Light	: Out LED on the front panel
Ambient Temperature	:-5 °C to + 50 °C
Installation	: Surface mounting or on the mounting rails.
Dimensions	: Type PK 25 Type PK 28
Protection Class	: IP 20
Weight	: 0.2 kg
Terminal Cable Crosssections	:(for PK-28) 4mm² (12AWG) solid conductor 6mm² (10AWG) stranded rigid conductor 2x2.5mm² (14AWG) solid conductor (for PK-25) 4mm² (12AWG) solid conductor 2,5mm² (14AWG) stranded rigid conductor 2x1,5mm² (2x16AWG) solid conductor

Liquid Level Electrode



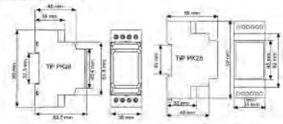
Note: The contact resistance at ohmic load (eg: Incandescent bulb, Resistance devices) is 8A. It is recommended to use a contactor if the inductive load eg: AC motor, fluorescent, etc.) or capacitive load (eg : Led Drivers, UPS, Fluorescent (Electronic Ballast), etc.) switch. Otherwise adhesion may occur in relay contacts.

Precautions For Installation And Safe Use

Failure to follow those instructions will result in death or serious injury.
- Disconnect all power before working on equipment.
- When the device is connected to the network, do not remove the front panel.
- Do not try to clean the device with solvent or the like. Only clean the device with a dried cloth.
- Verify correct terminal connections when wiring.
- Electrical equipment should be serviced only by your compedent seller.
- Mount device to the panel.

⚠ No responsibility is assured by the manufacturer or any of its subsidiariesfor any consequences arising out of the use of this material.

Dimensions



CE

A4988/Rev.3

2

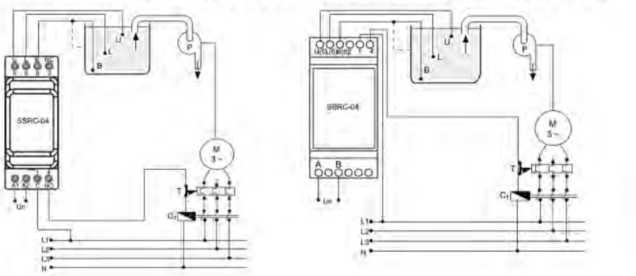
Technical Data

Operating Range (ΔU)	:Please look at labels on the device. : 190-260 V AC : 340-460 V AC
Rated Frequency (f)	: 50/60 Hz
Output Contacts	: 1 C/O, 8A, 2000 VA, Cosφ=1
Sensitivity (R(kΩ))	: Adjustable 5 - 50 kΩ
Warning Light	: Out LED on the front panel
Ambient Temperature	:-5 °C to + 50 °C
Installation	: Surface mounting or on the mounting rails.
Dimensions	: Type PK 25 Type PK 28
Protection Class	: IP 20
Weight	: 0.2 kg
Terminal Cable Crosssections	:(for PK-28) 4mm² (12AWG) solid conductor 6mm² (10AWG) stranded rigid conductor 2x2.5mm² (14AWG) solid conductor (for PK-25) 4mm² (12AWG) solid conductor 2,5mm² (14AWG) stranded rigid conductor 2x1,5mm² (2x16AWG) solid conductor

Precautions For Installation And Safe Use

Failure to follow those instructions will result in death or serious injury.
- Disconnect all power before working on equipment.
- When the device is connected to the network, do not remove the front panel.
- Do not try to clean the device with solvent or the like. Only clean the device with a dried cloth.
- Verify correct terminal connections when wiring.
- Electrical equipment should be serviced only by your compedent seller.
- Mount device to the panel.

Connection Diagram Type PK-28 **Connection Diagram Type PK-25**



4. Equipment for Energy Audit, Preventive and Breakdown maintenance:

Sr. No.	Name of Equipment
1	Power Analyzer
2	Power and Harmonics Clamp meter
3	Clamp meter
4	Insulation Resistance and Continuity Tester
5	Earth Tester
6	AC Voltage Detector
7	Ultrasonic Flow meter
8	Water Level meter
9	Pressure Gauge
10	Thickness probe

5. Activity on miniature Pumping Station:

Electrical:

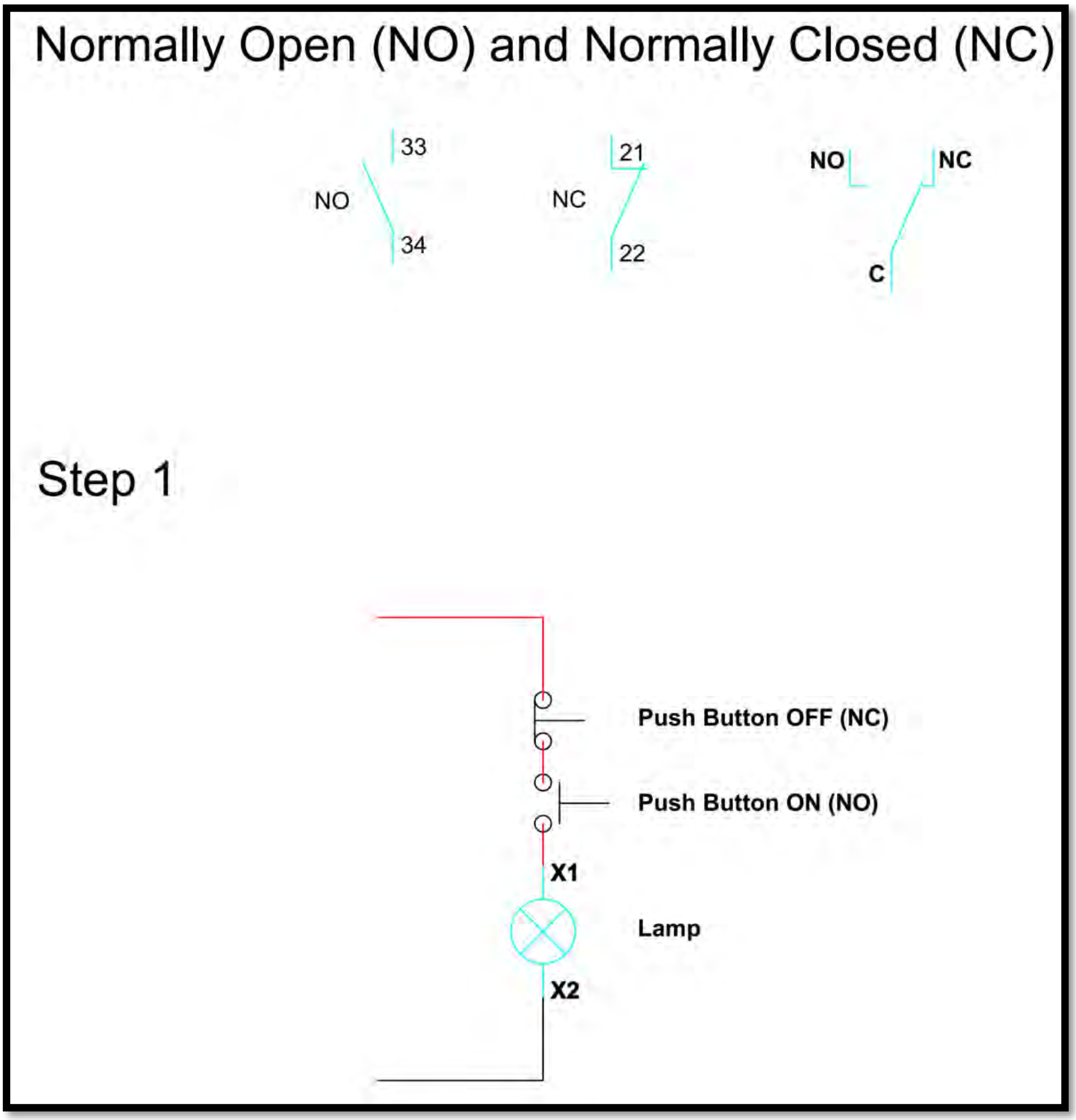
1. Energy Audit
2. Flow Rate and Current Relation
3. Operation of Over Current Relay
4. Operation of Liquid Level Controller
5. Understanding of Normally Open and Normally closed-circuit operations
6. Understanding Power and Control Circuit Drawings
7. Insulation Resistance Test

Mechanical:

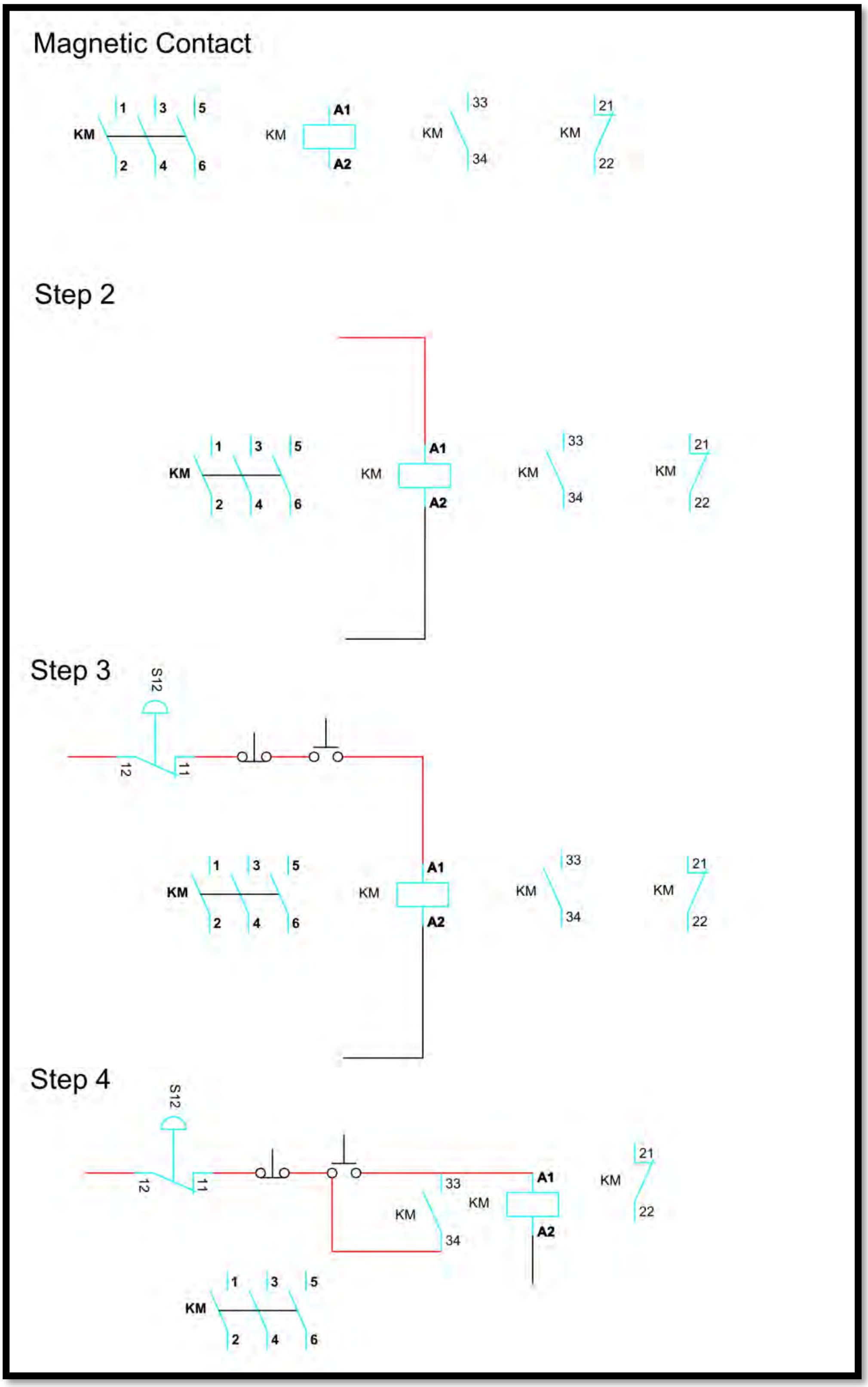
1. Series pump operation (Head/ Flow/ Pressure)
2. Parallel pump operation (Head/ Flow/ Pressure)
3. Operation and Maintenance of water meter
4. Advantages of strainer or screen
5. Installation of Ultrasonic flow meter
6. Discharge pressure and unit conversion
7. Pump Performance Curve/ Q-H curve
8. Operation and Maintenance of Chlorinator
9. Calibration of Chlorinator

6. Reading a simple circuit diagram and making circuit:

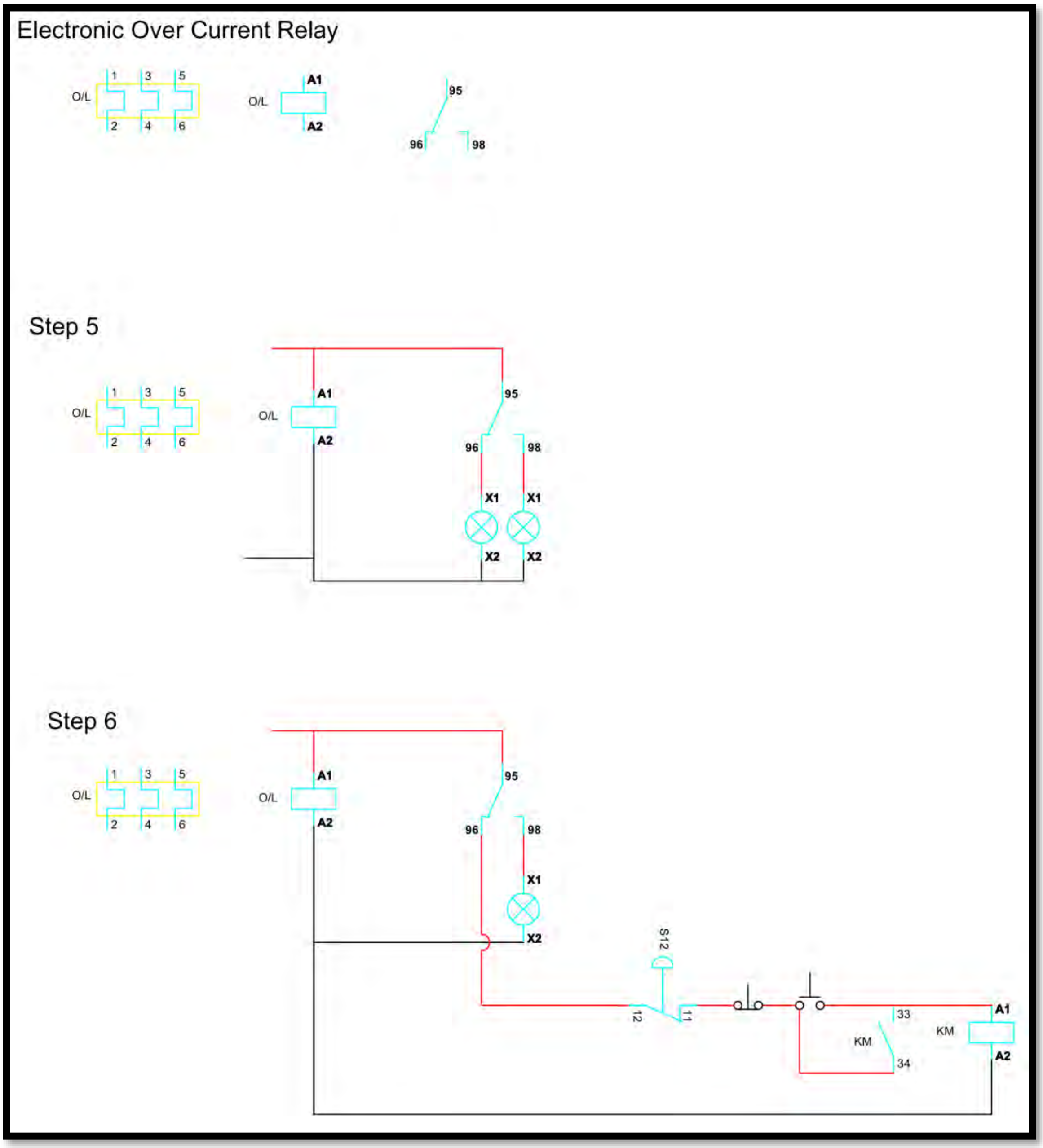
6.1 Normally open (NO) and normally closed (NC) circuit



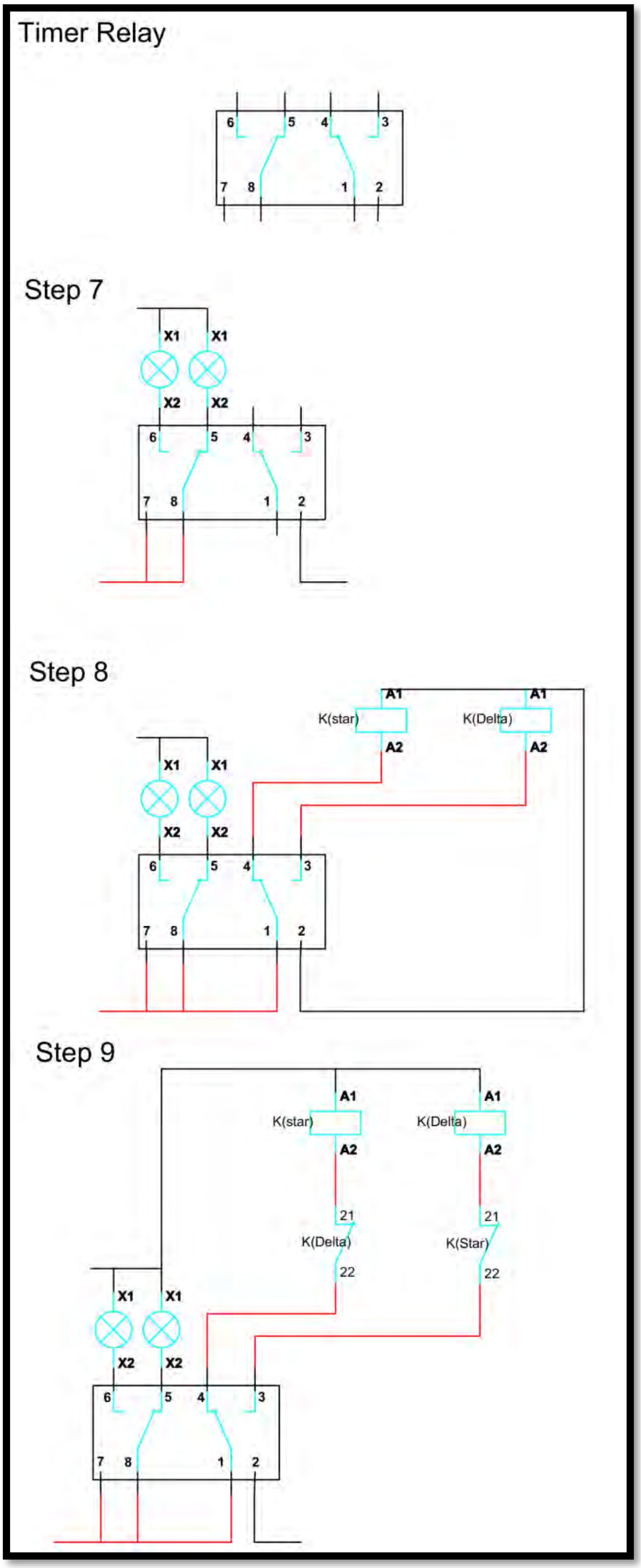
6.2 Connection of Magnetic Contactor



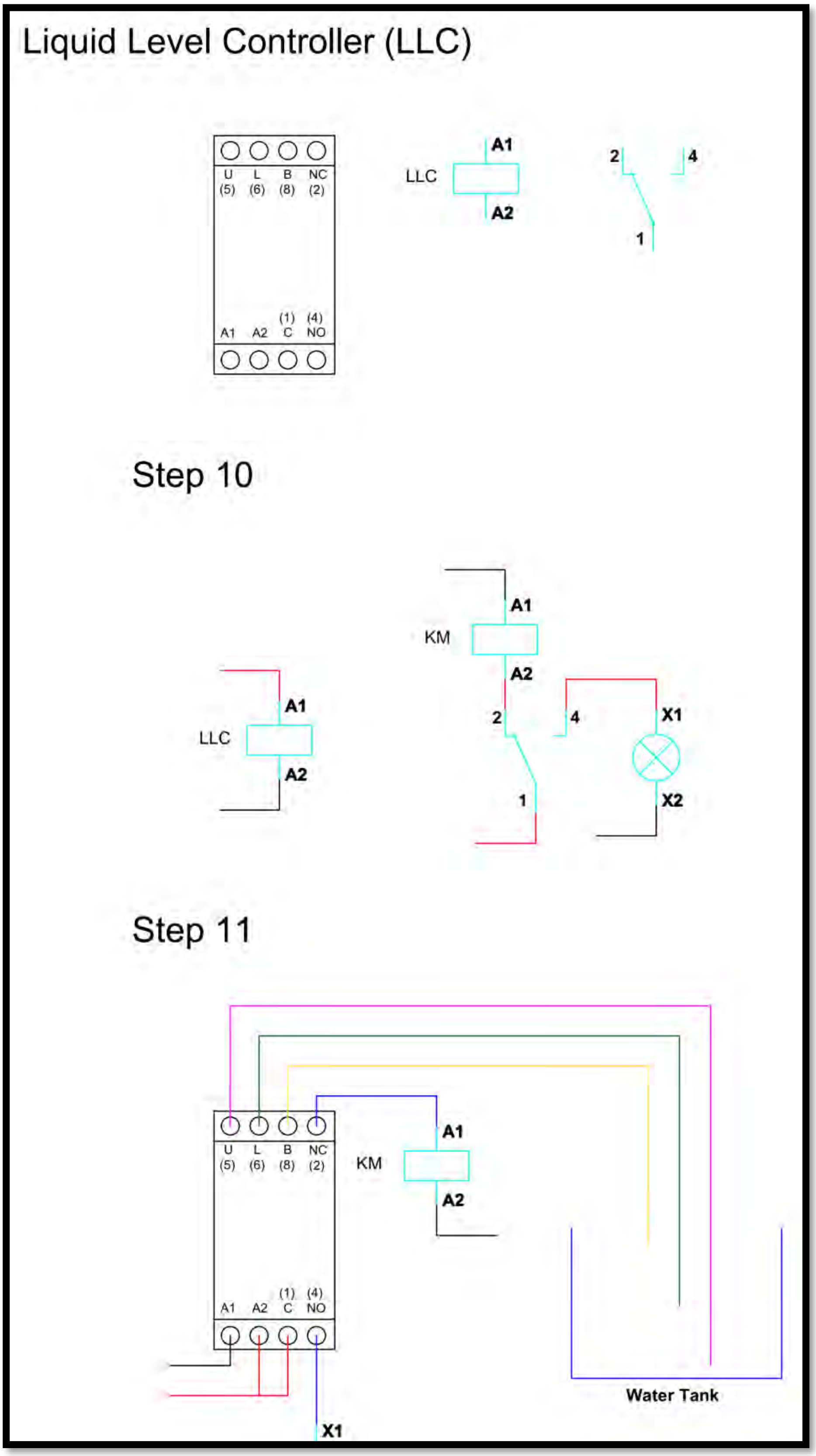
6.3 Connection of Electronic Over Current Relay



6.4 Connection of Timer Relay

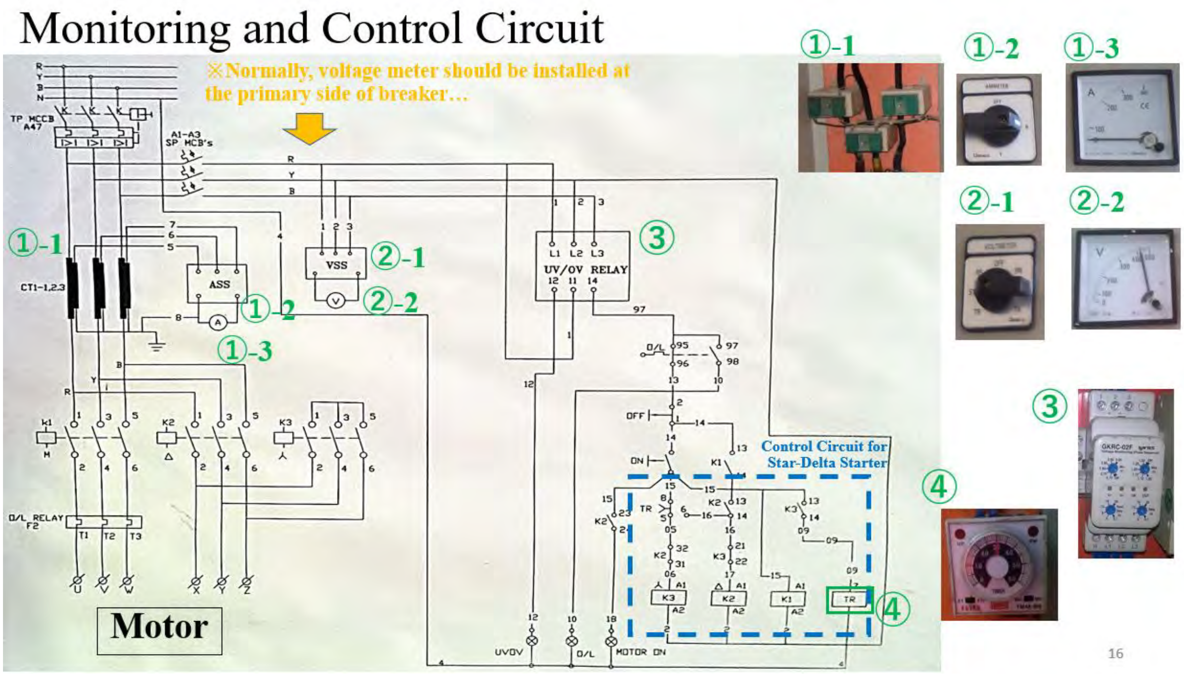


6.5 Connection of Liquid Level Controller



6.6 Adding monitoring devices and protection relays to the circuit

6.7 Constructing Star Delta panel circuit



List of Components

Motor Control Unit

MCC 80BHP/60KW for Motor 2-CFS Capacity Vertical Turbine Pump

Sr. No.	Components	Quantity	Purpose of each component
A.	Incoming		
01	MCCB TP 250A 18KA	01 No.	For Switching and Short Circuit Protection
02	MCB SP 6A 6KA	03 Nos.	For Control Circuit & Instrument Protection
03	Digital Ampere Meter 200A	01 No.	For Motor Running Load Monitoring
04	Ampere Selector Switch 4-Position	01 No.	For Selection of Phase to see Running load one by one
05	Digital Volt Meter 500 V	01 No.	For Line Voltage Confirmation
06	Voltage Selector Switch 4-Position	01 No.	For Selection of Phase to see Line Voltage one by one
07	Current Transformer 200/5A	03 Nos.	For Feeding the Secondary Current to Digital Ampere Meter
08	LED Type Indication Light	03 Nos.	For Phase in attendance (R-Y-B)
B.	80 BHP/60KW Auto Star Delta Switch		
01	Magnetic Contractor TP operational 85A	01 No.	For Main (Auto Star Delta)
02	Magnetic Contractor TP operational 85A	01 No.	For Delta (Auto Star Delta)
03	Magnetic Contractor TP operational 50A	01 No.	For Star (Auto Star Delta)
04	Over-Load relay Range 65A-100A	01 No.	For Thermal Over Load, Short circuit & Phase loss protection
05	Under/Over Voltage relay	01 No.	For Voltage Monitoring i.e. Under Voltage, Phase Failure & Phase Sequence Protection
06	Motor Thermistor Relay	01 No.	For Motor Winding Temperature Protection
07	LED Type Indication Light	02 Nos.	For ON/OFF Position Auto Star Delta Switch (Green & Red)
08	LED Type Indication Light	02 Nos.	For over load, under-over, thermistor protection Indication (Yellow)
09	Push Button 10A 1 NC / 1 NO (Green/Red)	02 Nos.	For ON/OFF Position Auto Star Delta Switch
10	Emergency Push Button	01 No.	For Emergency Stop of System
11	MCB SP 6A 6KA	01 No.	For Control Circuit Protection
12	Control Terminal	01 Set	For the Control Circuit Connectivity

C.	25 KVAR Power Factor Improvement Plant		
01	Analogue Power Factor Meter	01 No.	For Displaying of Power Factor (it may lead or lag)
02	Power Capacitor 25KVAR	01 No.	For Low Power Factor Compensation
03	Magnetic Contractor TP operational 40A	01 No.	For 25KVAR Capacitor Switching
04	63A HRC Fuses with Base	02 Nos.	For Capacitor 25KVAR Over Load and Short Circuit Protection
05	LED Type Indication Light	01 No.	For ON/OFF Position of 25KVAR Power Capacitor (Green)
06	Push Button 10A 1 NC/1NO	02 Nos.	For ON/OFF Position of 25KVAR Power Capacitor (Green/Red)
07	Auto Manual Selector Switch	01 No.	For the Selection Mode of Automatic and Manual Switching
08	Surge Suppressor	01 Set	Protect from Voltage Spikes

Facility Failure Analysis

By

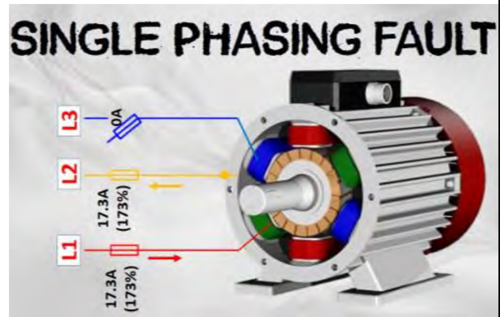
Jawad Shahid

1. What happens if shaft of a pump breaks during operation for a vertical turbine pump for Disposal Station

Explanation:

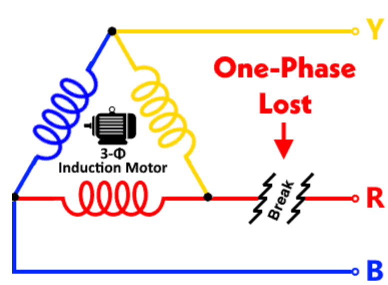
2. What happens if one phase of power supply fails during operation of Pump and Motor, explain in a step-wise approach.

Condition 1: With protective relays installed and calibrated.



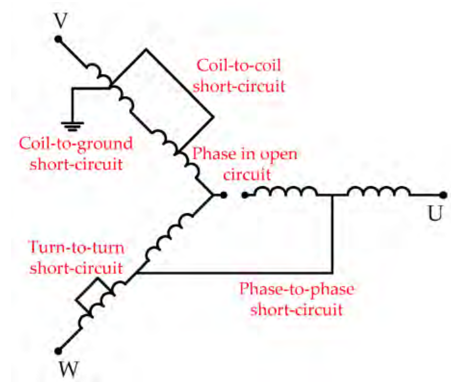
2. What happens if one phase of power supply fails during operation of Pump and Motor, explain in a step-wise approach.

Condition 2: All protective relays by-passed.



3. What happens if during operation of a tube-well two windings of a motor short circuit (Motor Burnout).

Condition 1: Protective relays installed and calibrated.



3. What happens if during operation of a tube-well two windings of a motor short circuit (Motor Burnout).

Condition 2: Protective relays by-passed

4. Shaft of a vertical turbine tube-well breaks during operation.

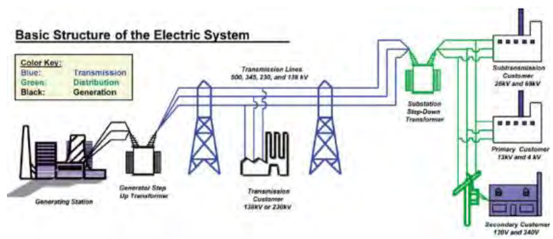
Condition 1: With all relays installed and calibrated.

4. Shaft of a vertical turbine tube-well breaks during operation.

Explanation:

5. During operation of Pump and Motor two phases are interchanged from distribution end (DISCO)

Condition 1: With use of protective relays.



5. During operation of Pump and Motor two phases are interchanged from distribution end (DISCO)

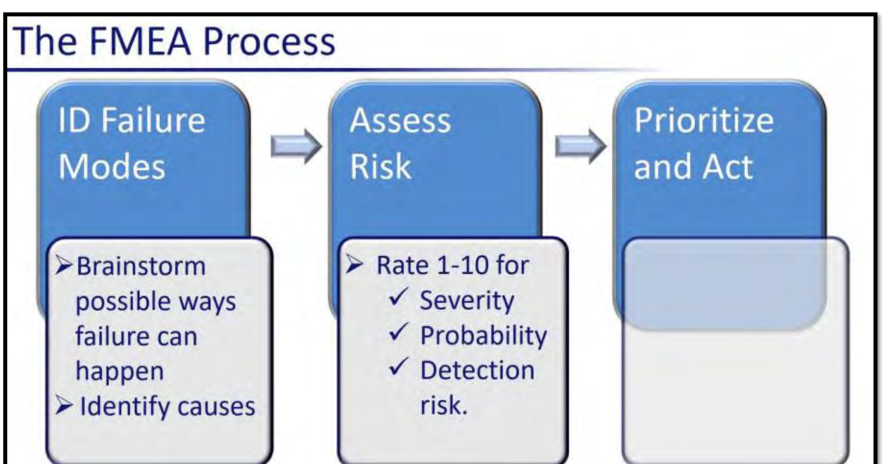
Condition 2: With all protective relays by-passed.

Basics of Motor Protection

Motor Protection

- E — Earth Fault Protection
- P — Phase Unbalance Protection
- O — Overload Protection
- L — Locked Rotor Protection
- S — Short Circuit Protection

Failure Mode and Effects Analysis (FEMA)



Failure Mode and Effects Analysis (FEMA)

	CONSEQUENCES					PROBABILITY				
						1	2	3	4	5
Severity	Classification	Safety	Equipment/ Maintenance Cost	Production	Environmental	< 1% Remote	1% - 5% Extremely Unlikely	5% - 25% Very Unlikely	25% - 50% Unlikely	> 50% Likely
5	Disastrous	Multiple fatalities, > 5. Large effects on large external inhabited zones-several fatalities	Extensive damage >$8M	Major loss, not recoverable. More than 3 days lost production	Major pollution with sustained environmental consequences external to the site	5	10	15	20	25
4	Catastrophic	Lethal effect on several persons (several fatalities). Lethal external effect - one fatality, several physical injuries	Major damage $6M-$8M	Major loss. Up to 50% not recoverable Up to 3 days lost production	Major pollution external to the site. Evacuation of persons	4	8	12	16	20
3	Major	Lethal effect on one person and/or several permanent invalidities. Permanent external effects	Localized damage $2M - $6M	Medium loss, not wholly recoverable through normal production < 24 hours lost production	Moderate pollution, within site limits. Product liability	3	6	9	12	15
2	Serious	Permanent injury, lost time accident. Non-permanent external effects	Minor damage $200K - $2M	Minor loss, recoverable through normal production 2 to 8 hours lost production	Spill or release of pollutant requiring a declaration to authorities but without environmental consequences	2	4	6	8	10
1	Moderate	No permanent injury, recordable with no lost time/medical treatment. No external effect	Slight damage < $200K	Little to no effect. Production easily recovered. < 2 hour lost production.	Minor spill or release of pollutant, not requiring a declaration	1	2	3	4	5

Risk Assessment Matrix

Risk Matrix

A	B	C	D	E	F
Initial Occurrence	Initial Severity				
	1 - Insignificant	2 - Minor	3 - Significant	4 - Serious	5 - Major
5 - High			1	2	
4 - Moderate			3	5	
3 - Low			1	2	
2 - Very Low					
1 - Remote					

Risk Assessment Matrix (Example)

Initial Occurrence	Initial Severity				
	1 Insignificant	2 Minor	3 Significant	4 Serious	5 Major
5 High					
4 Moderate			Chlorine dosing pump failure		Burnout of MCCB for MCU
3 Low					
2 Very Low		Power Factor Capacitor Failure	Chlorine dosing pump failure		
1 Remote					

Preventative Mainteniance Schedule of Switchgear / Controlgear

Date: / /		Approved by (Engineer)	
Facility:		Prepared by	

S.No.	Maintenaince Objective	Due Time	Time Schedule (Week)																									
		Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	Dusting and Cleaning of complete equipment with blower, etc	4 Weeks																										
2	Checking of tripping and ON / OFF operation of all breakers contactors and relays	4 Weeks																										
3	externally while switching the main switch OFF	12 Weeks																										
4	thimbles for proper connection and heat signature wit Infra-red sensor	12 Weeks																										
5	Tightening of all terminations	12 Weeks																										
6	Infrared imaging of control panel to observe unusual heat signature	12 Weeks																										
7	Insulation test to ensure proper insulation of Cables	16 Weeks																										
8	Checking of Intrusion path for proper vermin protection	12 Weeks																										
9	Cleaning of Open Contact with contact spray cleaner	24 Weeks																										
10	Calibration of measuring devices and instrument relays	52 Weeks																										
11	Checking of Voltage for all Three Phases V(RY), V(RB), V(YB)	12 Weeks																										
12	Checking of Current of all Three Phases	12 Weeks																										
13	Checking of Power Factor Value	12 Weeks																										

14	Earth Resistance test of MCU and Motor	26 Weeks																										
15	Any other task as per manufacturer's recommendation or Engineer incharge																											
Remarks and Observations																												

Developed in Technical Assistance of PEMPAK

Preventative Maintenaince Schedule of Motor

Date: / /	Approved by (Engineer)	
Facility:	Prepared by	

S.No.	Maintenaince Objective	Due Time	Time Schedule (Week)																							
		Weeks	4	8	12	16	20	24	30	34	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108
1	Visual inspection including cleaning, dusting and greasing	4																										
2	Examination and reporting of vibration, bearings sound, termination and coupling arrangement / allignment	4																										
3	Thermographic Survery, temperature monitoring and recording	12																										
4	Load verification w.r.t to manufacturer's data and	12																										
5	Insulation Test	52																										
6	Inspection of Bearing	52																										
7	P.F verification of Motor and P.F.I Equipment	52																										
8	Earth Resistance Test	24																										
9	Any other task assigned by Engineer incharge																											

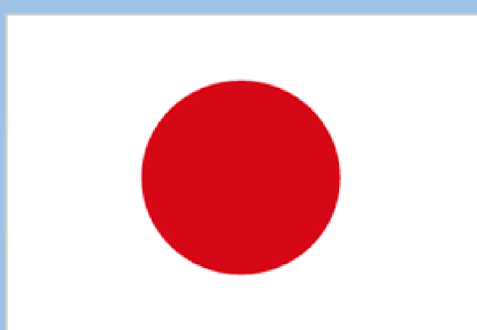
Remarks and Observations

Developed in Technical Assistance of

PEMPAK

Annex 5.1.50 Training Material for "O&M of Sewerage and Drainage" in Fall 2022

In the name of Allah, the most Gracious and ever Merciful



Introduction

Welcome To All Stakeholders

Course Team

Mr. Tomidokoro	JICA Expert
Mr. Syed Fahad Hussain	Course Leader Sewerage & Drainage System
Mr. Muhammad Irfan	Specialist Infrastructure

Operation and Maintenance (O&M) of Sewerage and Drainage System

Code: S 3221

Modules 03

Duration 03 Days

Class Work
Field Work

Introduction

Modules

Module 1
- Cleaning of Sewerage & Drainage Pipelines
- 01 Day

Module 2
- Flow Measurement
- 01 Day

Module 3
- Wastewater Testing & Flow Rate Measurement
- 01 Day

Introduction

WHAT WILL ANIMATE THE TRAINING SESSION. . .

Mini Lectures → Video Clips → Discussions → On-Site-Training → Case Histories → Q&A → Presentations

Introduction

INSPECTION OF SEWER / MANHOLE

Objectives of Sewer Inspection

- To identify existing or potential problems in Sewer / Manhole
- To examine structure of the Sewer / manhole
- To observe functional capacity of Sewer / manhole

INSPECTION METHODS

- Visual
- Camera

Visual Inspection

Arrangements before Inspection:

• Map of the Collection System	• Scrapers and Wire Brushes for Cleaning the Manhole Ring
• Metal Detector	• Powerful Flashlight
• Warning Devices, Safety Cones and Traffic Safety Devices	• Gas Detection Devices
• Manhole Lid Removal Device	• Blower and Hose for Ventilating Manhole
• Leather Gloves	

Categories of Visual Inspection…

Initial Inspection

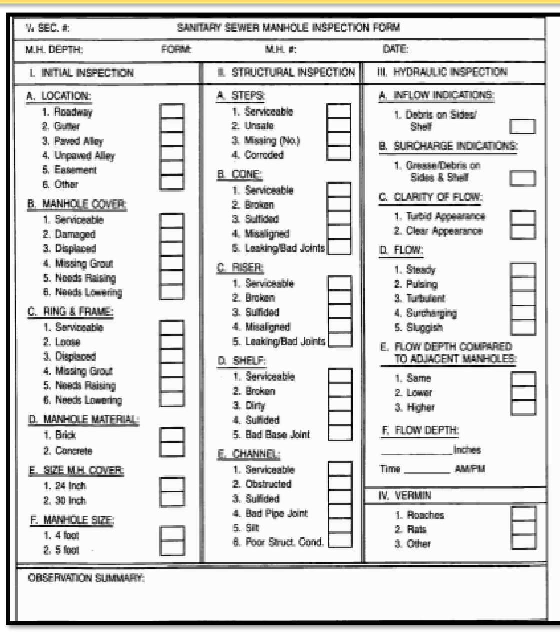
- Location
- Manhole Cover
- Ring & Frame
- Manhole Material
- Sizes

Structural Inspection

- Steps
- Cone
- Riser
- Shelf
- Channel

Hydraulic Inspection

- Inflow
- Clarity
- Flow
- Flow Depth
- Vermin



¼ SEC. #: SANITARY SEWER MANHOLE INSPECTION FORM

M.H. DEPTH: FORM: M.H. #: DATE:

I. INITIAL INSPECTION

A. LOCATION:
1. Roadway
2. Gutter
3. Paved Alley
4. Unpaved Alley
5. Easement
6. Other

B. MANHOLE COVER:
1. Serviceable
2. Damaged
3. Displaced
4. Missing Grout
5. Needs Raising
6. Needs Lowering

C. RING & FRAME:
1. Serviceable
2. Loose
3. Displaced
4. Missing Grout
5. Needs Raising
6. Needs Lowering

D. MANHOLE MATERIAL:
1. Brick
2. Concrete

E. SIZE M.H. COVER:
1. 24 Inch
2. 30 Inch

F. MANHOLE SIZE:
1. 4 foot
2. 5 foot

II. STRUCTURAL INSPECTION

A. STEPS:
1. Serviceable
2. Unsafe
3. Missing (No.)
4. Corroded

B. CONE:
1. Serviceable
2. Broken
3. Sulfided
4. Misaligned
5. Leaking/Bad Joints

C. RISER:
1. Serviceable
2. Broken
3. Sulfided
4. Misaligned
5. Leaking/Bad Joints

D. SHELF:
1. Serviceable
2. Broken
3. Dirty
4. Sulfided
5. Bad Base Joint

E. CHANNEL:
1. Serviceable
2. Obstructed
3. Sulfided
4. Bad Pipe Joint
5. Silt
6. Poor Struct. Cond.

III. HYDRAULIC INSPECTION

A. INFLOW INDICATIONS:
1. Debris on Sides/ Shelf

B. SURCHARGE INDICATIONS:
1. Grease/Debris on Sides & Shelf

C. CLARITY OF FLOW:
1. Turbid Appearance
2. Clear Appearance

D. FLOW:
1. Steady
2. Pulsing
3. Turbulent
4. Surcharging
5. Sluggish

E. FLOW DEPTH COMPARED TO ADJACENT MANHOLES:
1. Same
2. Lower
3. Higher

F. FLOW DEPTH:
_______ Inches
Time _______ AM/PM

IV. VERMIN
1. Roaches
2. Rats
3. Other

OBSERVATION SUMMARY:

Manhole Inspection Form

Screening Camera For Sewer Inspection

Objectives of Screening Camera

1. To look for damages / breaks in sewer line
2. To locate root intrusion
3. To find unrecorded connection
4. To locate protruding laterals
5. To locate cracks / inflow sources
6. To search lost / buried lines
7. To verify alignment

Components of Camera

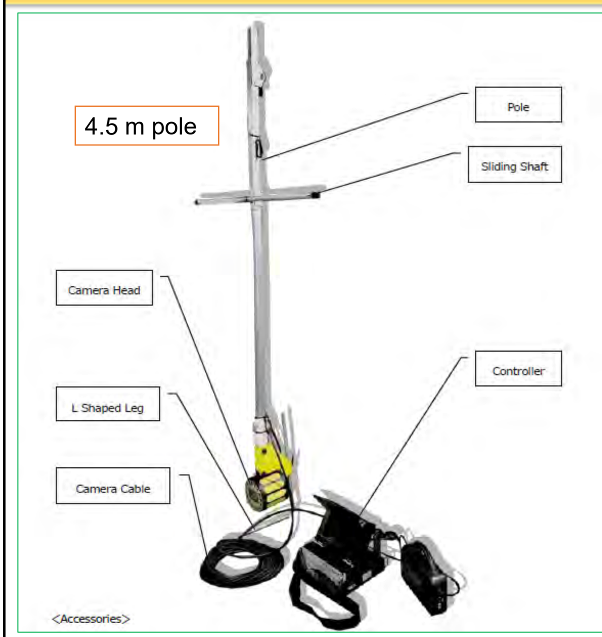
System

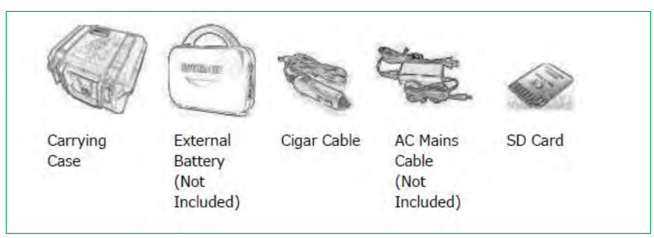
1) Camera Head .... 1 pc
2) Camera Cable (10m) .... 1 pc
3) Controller .... 1 pc
4) Pole (4.5m : 3-stage telescopic) .... 1 pc

Accessories

1) Carrying Case .... 1 pc
2) SD Card .... 1 pc
3) Cigar Cable .... 1 pc
4) AC Mains Cable .... 1 pc
5) Instruction Manual (this document) .... 1 pc

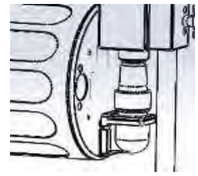
Components of Camera

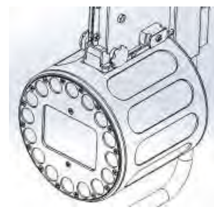




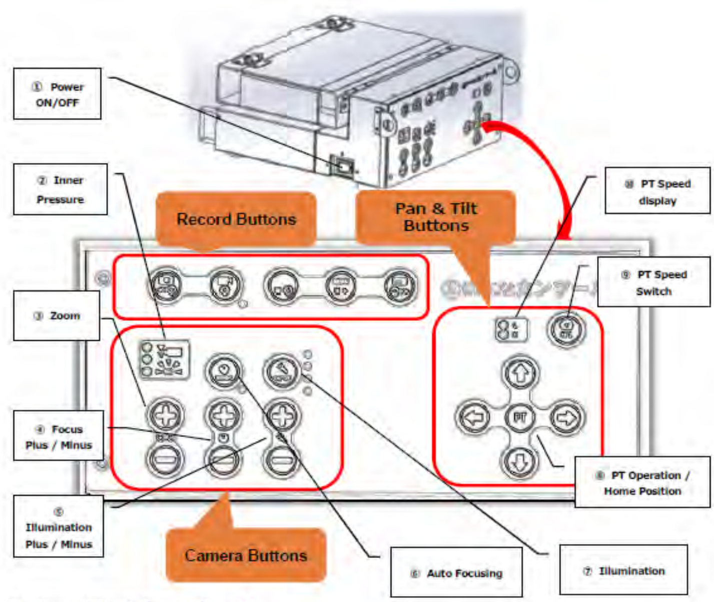
How to Connect Device

1. Take out the camera head and the camera cable from the carrying case.
2. Connect the camera head to the camera cable
3. Take out the controller from the carrying case.
4. Connect the controller to the camera cable.
5. Connect the pole to the camera head



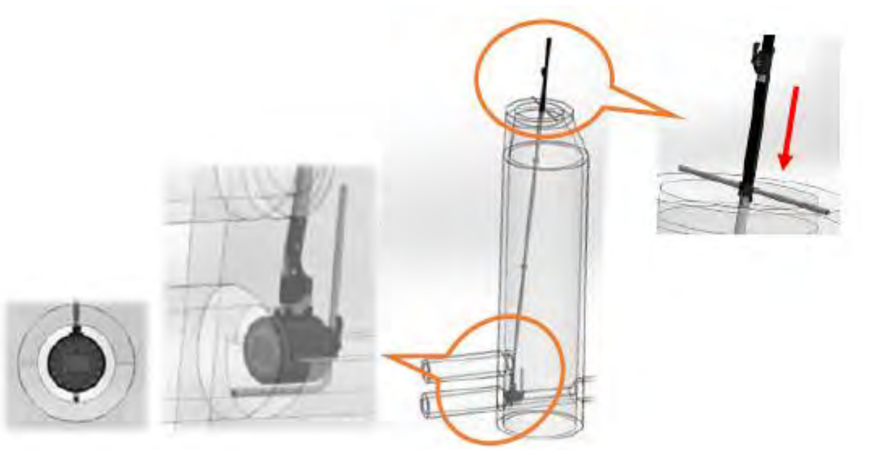


How to Operate (Overview)



① Power ON: I Power OFF: O

Installation into the Manhole



Recording (Video/Still Image)

Video recording time (estimate)

Picture quality	4GB	8GB	16GB	32GB
Highest	About 48 min	About 96 min	About 190 min	About 380 min
High	About 60 min	About 120 min	About 240 min	About 480 min
Normal	About 80 min	About 160 min	About 320 min	About 640 min

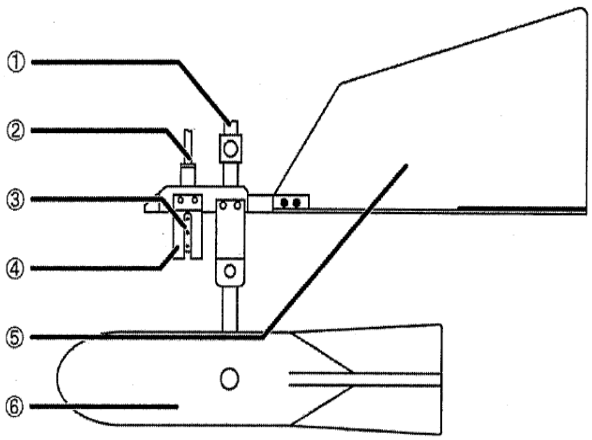
WASA Rawalpindi (Pictures)

Propeller Type Velocity Meter

Operational Principle

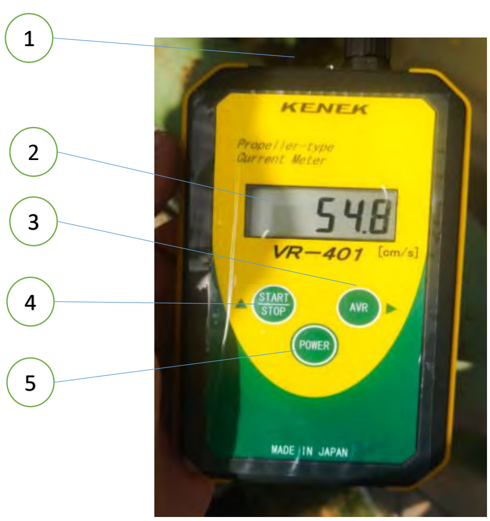
Propeller rotational speed is detected by means of magnet embedded in the propeller which is then converted into velocity by the main unit and displayed

Operational Principle



1. **Mounting Bracket**
2. **Connector Holder**
3. **Propeller**
4. **Protective Ring**
5. **Flowing Wing**
6. **Weight**

Operational Principle

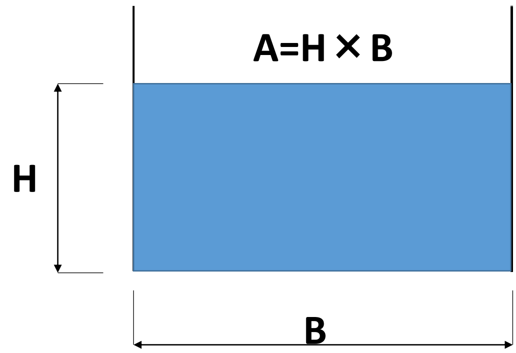


1. **Output Connector**
2. **Display Window**
3. **Avg Time Button**
4. **Start / Stop Button**
5. **Power Button**

Flow Measurement of Open Channels

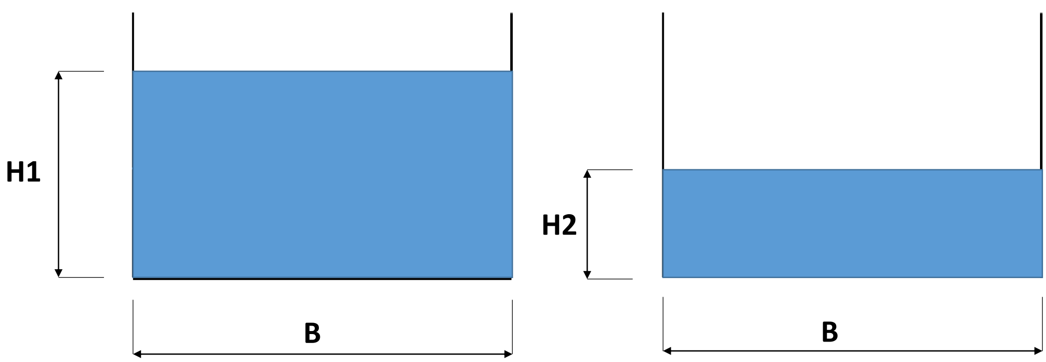
Q=A*V

- **Q : Flow Rate**
- **A : Area**
- **V : Velocity**



Open Channel : Area & Velocity

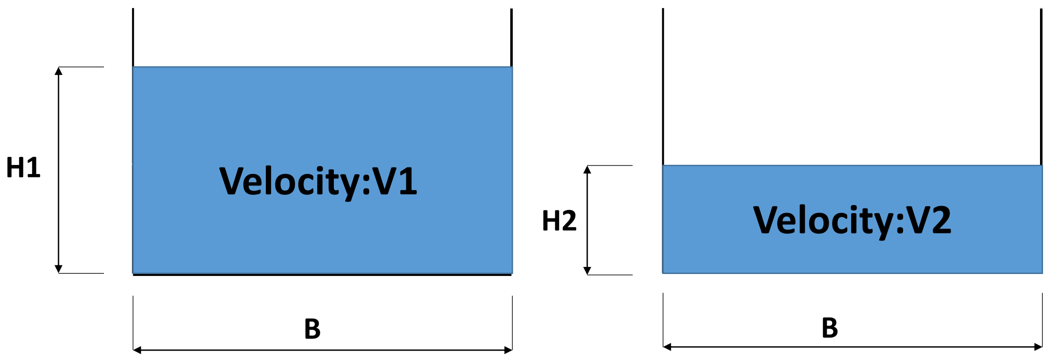
1) Area



A1=H1 × B

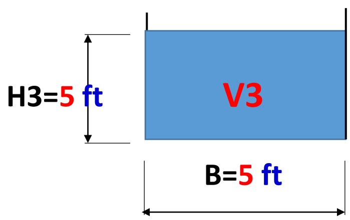
A2=H2 × B

2) Velocity



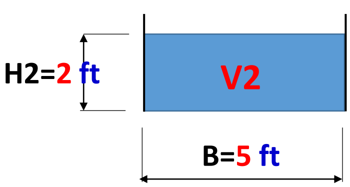
※ Flow velocity depends on the water level position to be measured.

Flow Measurement of Open Channels

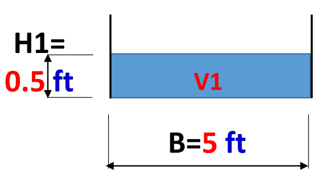


A3= H*B ＝ ft2
V3=4.36 ft/s
Q3= *4.36
= ft3/s
(cusec)

H-Q(Height-Quantity) Curve



A2=H*B ＝ ft2
V2=3.32 ft/s
Q2= *3.32
= ft3/s
(cusec)



A1= H*B ＝ ft2
V1=1.73 ft/s
Q1= *1.73
= ft3/s
(cusec)

※ft3/s＝cusec

Selection of Best Wastewater Treatment Technologies

General Characteristics of Wastewater

Parameters	Low	High
BOD	Clean	Polluted
COD	Clean	Polluted
pH	Acidic	Alkaline
DO	Polluted	Clean

General Characteristics of Treatment Technologies

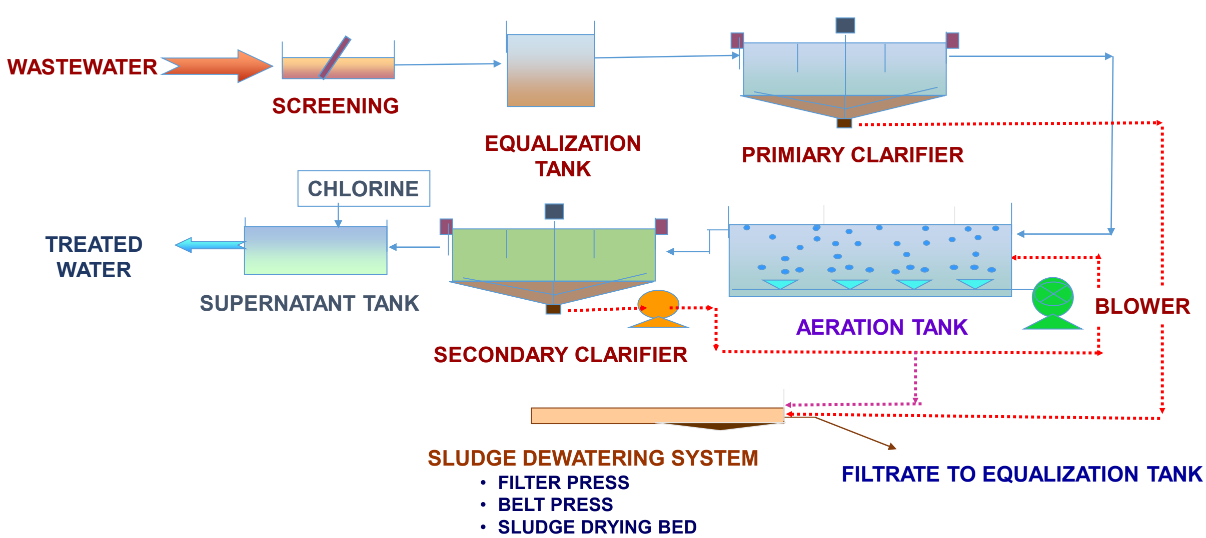
Influent → Big Particles → Small Particles → Dissolved Particles → Effluent

General Characteristics of Treatment Technologies

Treatment Technologies	Big Particles	Small Particles	Dissolved Particles
Conventional Activated Sludge (more mechanical + Biological)	Screen	Grit Chamber	Aeration Tank & Secondary Clarifier
Aerated Lagoon (less mechanical + Biological)	Screen	None	Aerated Lagoons
Waste Stabilization Pond (Biological)	Screen/None	None	Ponds

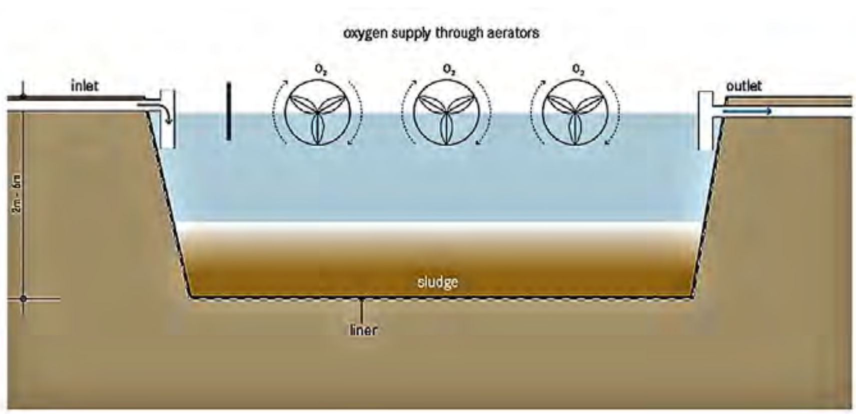
Activated Sludge Process (Aeration Tank)

Activated Sludge Process

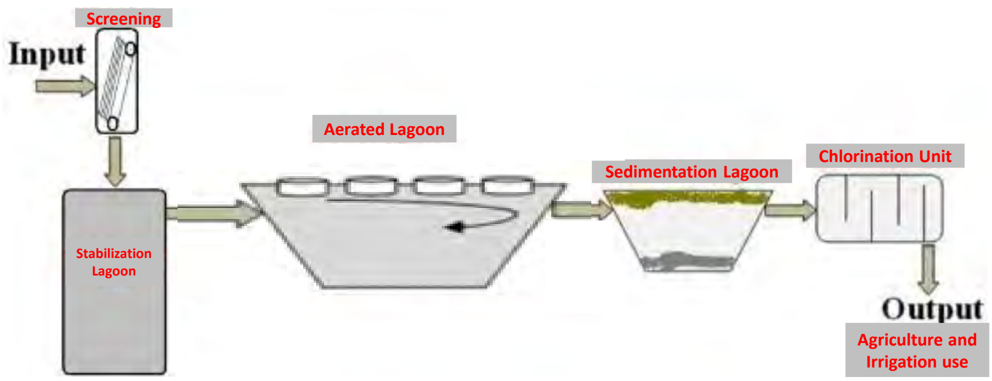


Aerated Lagoons

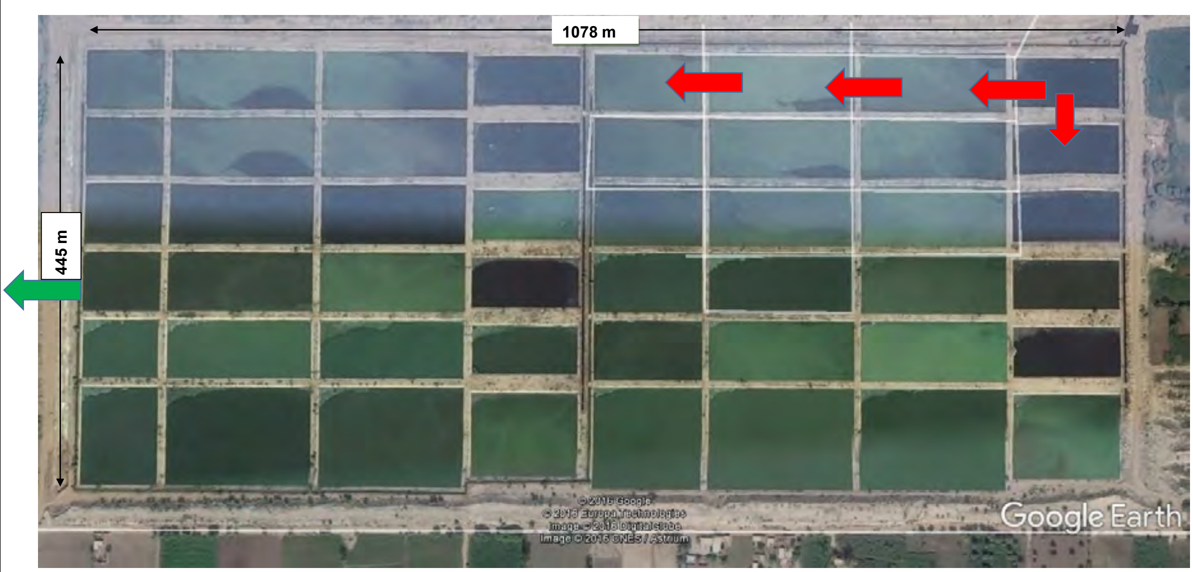
Aerated Lagoons Process



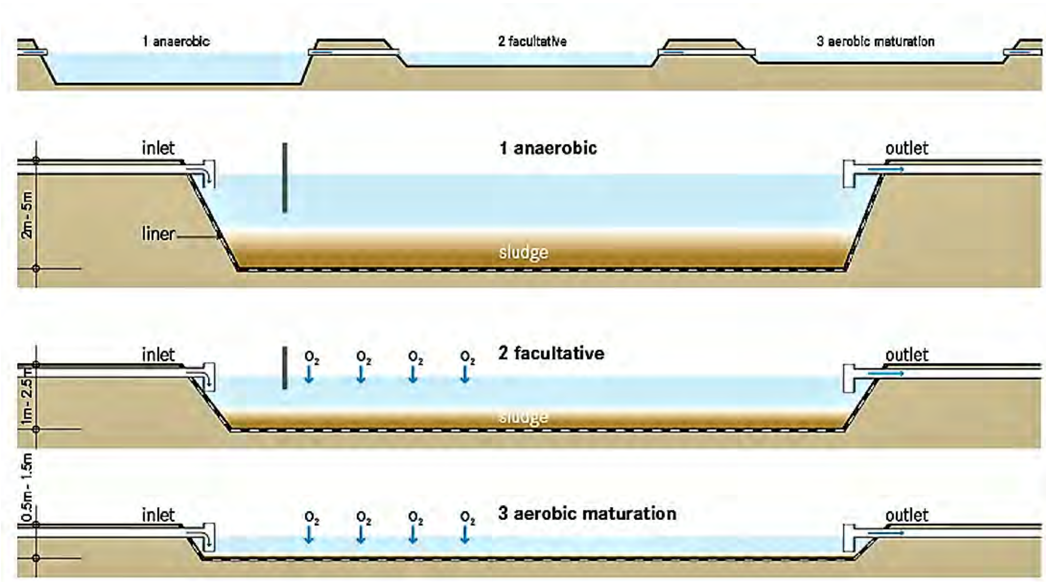
Aerated Lagoons Process



Waste Stabilization Ponds



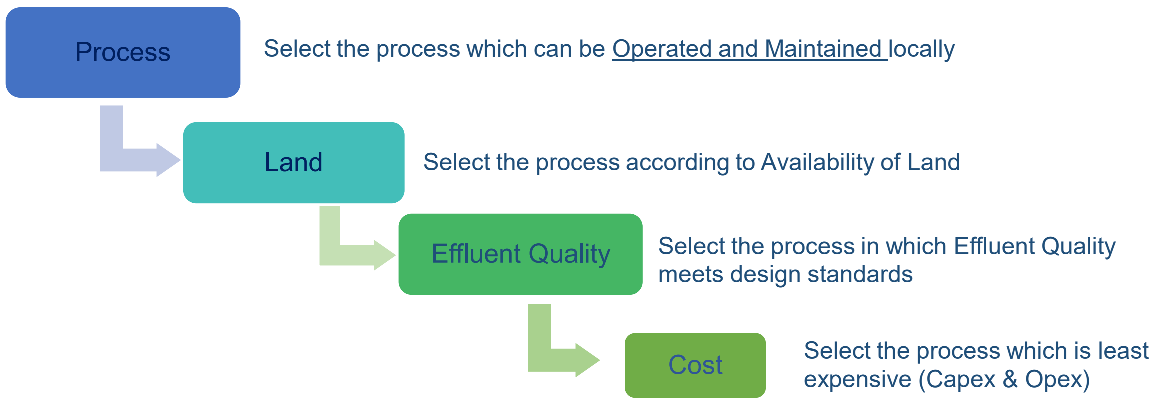
Waste Stabilization Pond



General Characteristics of Treatment Technologies

Treatment Technologies	Effluent (BOD)	Removal Efficiency	Area Req.	Capital Cost without land cost	Operational Cost
Conventional Activated Sludge	Very good	Very good	Small	High	High
Aerated Lagoon	Good	Good	Medium	Medium	Medium
Waste Stabilization Pond	Fair	Fair	Large	Low	Low

Process of selecting best Wastewater Treatment Technology



Example No. 1:
Step 1: Select the process which can be <u>Operated and Maintained</u> locally.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge			**10**	**20**	**100**	
Aerated Lagoon	**15**	**100**	**20**	**50**	**50**	
Waste Stabilization Pond			**30**	**70**	**30**	

Example No. 1:
Step 1: Select the process which can be Operated and Maintained locally.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge			**10**	**20**	**100**	**Selected**
Aerated Lagoon	**15**	**100**	**20**	**50**	**50**	**Selected**
Waste Stabilization Pond			**30**	**70**	**30**	**Selected**

Example No. 1:
Step 2: Select the process according to Availability of Land.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge			**10**	**20**	**100**	
Aerated Lagoon	**15**	**100**	**20**	**50**	**50**	
Waste Stabilization Pond			**30**	**70**	**30**	

Example No. 1:

Step 2: Select the process according to Availability of Land.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge			**10**	**20**	**100**	**Selected**
Aerated Lagoon	**15**	**100**	**20**	**50**	**50**	
Waste Stabilization Pond			**30**	**70**	**30**	

Process of selecting best Wastewater Treatment Technology

Process — Select the process which can be Operated and Maintained locally

Land — Select the process according to Availability of Land

Effluent Quality — Select the process in which Effluent Quality meets design standards

Cost — Select the process which is least expensive (Capex & Opex)

Example No. 2:
Step 1: Select the process which can be Operated and Maintained locally.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	50	30	10	20	100	
Aerated Lagoon			20	50	50	
Waste Stabilization Pond			30	70	30	

Example No. 2:
Step 1: Select the process which can be Operated and Maintained locally.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	50	30	10	20	100	**Selected**
Aerated Lagoon			20	50	50	**Selected**
Waste Stabilization Pond			30	70	30	**Selected**

Example No. 2:
Step 2: Select the process according to Availability of Land.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	50	30	10	20	100	
Aerated Lagoon			20	50	50	
Waste Stabilization Pond			30	70	30	

Example No. 2:
Step 2: Select the process according to Availability of Land.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	50	30	10	20	100	Selected
Aerated Lagoon			20	50	50	Selected
Waste Stabilization Pond			30	70	30	Selected

Example No. 2:
Step 3: Select the process in which Effluent Quality meets design standards.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	50	30	10	20	100	
Aerated Lagoon			20	50	50	
Waste Stabilization Pond			30	70	30	

Example No. 2:
Step 3: Select the process in which Effluent Quality meets design standards.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	50	30	10	20	100	Selected
Aerated Lagoon			20	50	50	
Waste Stabilization Pond			30	70	30	

Process of selecting best Wastewater Treatment Technology

Process — Select the process which can be Operated and Maintained locally

Land — Select the process according to Availability of Land

Effluent Quality — Select the process in which Effluent Quality meets design standards

Cost — Select the process which is least expensive (Capex & Opex)

Example No. 3:
Step 1: Select the process which can be Operated and Maintained locally.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge			10	20	100	
Aerated Lagoon	25	60	20	50	50	
Waste Stabilization Pond			30	70	30	

Example No. 3:
Step 1: Select the process which can be Operated and Maintained locally.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	25	60	**10**	**20**	**100**	**Selected**
Aerated Lagoon			**20**	**50**	**50**	**Selected**
Waste Stabilization Pond			**30**	**70**	**30**	**Selected**

Example No. 3:
Step 2: Select the process according to Availability of Land.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	**25**	**60**	**10**	**20**	**100**	
Aerated Lagoon			**20**	**50**	**50**	
Waste Stabilization Pond			**30**	**70**	**30**	

Example No. 3:
Step 2: Select the process according to Availability of Land.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	Available Area	Design Standards: Effluent BOD	Minimum Required Area	Achievable Water Quality Effluent BOD	Estimated Cost (Capex & Opex)	Evaluation
Conventional Activated Sludge	25	60	10	20	100	Selected
Aerated Lagoon			20	50	50	Selected
Waste Stabilization Pond			30	70	30	Not Selected

Example No. 3:
Step 3: Select the process in which Effluent Quality meets design standards.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	Available Area	Design Standards: Effluent BOD	Minimum Required Area	Achievable Water Quality Effluent BOD	Estimated Cost (Capex & Opex)	Evaluation
Conventional Activated Sludge	25	60	10	20	100	
Aerated Lagoon			20	50	50	
Waste Stabilization Pond			30	70	30	Out of comparison

Example No. 3:
Step 3: Select the process in which Effluent Quality meets design standards.

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	25	60	**10**	**20**	**100**	**Selected**
Aerated Lagoon			**20**	**50**	**50**	**Selected**
Waste Stabilization Pond			**30**	**70**	**30**	**Out of comparison**

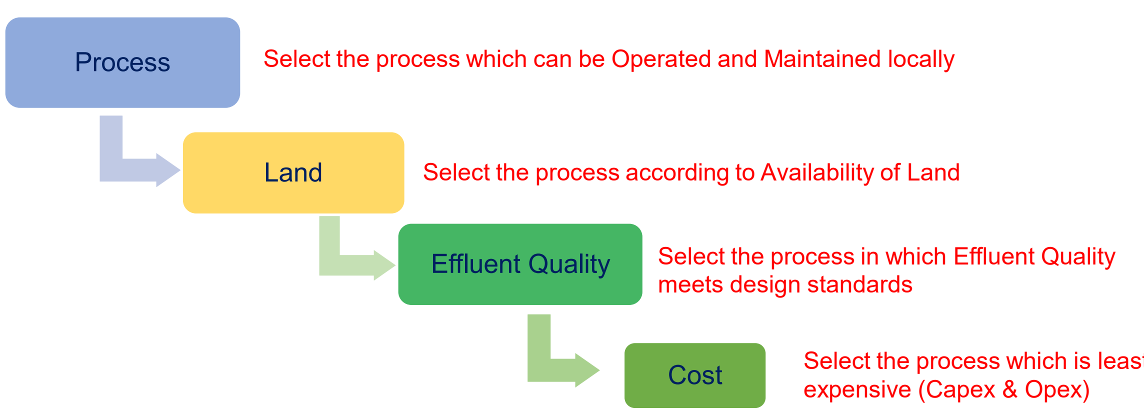
Example No. 3:
Step 4: Select the process which is least expensive (Capex & Opex).

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	25	60	**10**	**20**	**100**	
Aerated Lagoon			**20**	**50**	**50**	
Waste Stabilization Pond			**30**	**70**	**30**	**Out of comparison**

Example No. 3:
Step 4: Select the process which is least expensive (Capex & Opex).

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge			**10**	**20**	**100**	
Aerated Lagoon	**25**	**60**	**20**	**50**	**50**	**Selected**
Waste Stabilization Pond			**30**	**70**	**30**	**Out of comparison**

Process of selecting best Wastewater Treatment Technology



Exercise No. 1

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	25	30	10	20	100	
Aerated Lagoon			20	50	50	
Stabilization Pond			30	70	30	

Exercise No. 2

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	25	60	10	20	100	
Aerated Lagoon			20	50	50	
Stabilization Pond			30	70	30	

Exercise No. 3

Step 1	Step 2	Step 3	Step 2	Step 3	Step 4	
Treatment Technologies	**Available Area**	**Design Standards: Effluent BOD**	**Minimum Required Area**	**Achievable Water Quality Effluent BOD**	**Estimated Cost (Capex & Opex)**	**Evaluation**
Conventional Activated Sludge	40	80	**10**	**20**	**100**	
Aerated Lagoon			**20**	**50**	**50**	
Stabilization Pond			**30**	**70**	**30**	

Break

JICA STUDY

Preparatory Study for Lahore Water Supply, Sewerage and Drainage Improvement Project

Case Study

South West Treatment Plant

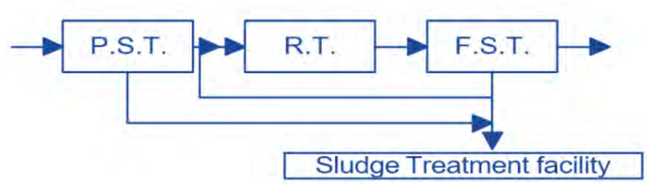
Comparison of Wastewater Treatment Systems

Criteria	Trickling Filter	Activated Sludge	Oxidation Ditch	Aerated Lagoon	Stabilization Pond	UASB
BOD_5	++	++	+++	+++	+++	+
Effluent Reuse Possibilities	+[1]	+[1]	++	+++	+++	+
Land Requirement	+++	+++	+++	++	++	+++
Maintenance Cost/ Energy Demand	++	+	+	+	+++	+++
Minimization of Sludge for Removal	++[2]	++[2]	+	++	+++	++

+++ (Good)
++ (Fair)
+ (Poor)

1. The effluents from activated sludge, trickling filter frequently have high ammonia levels (>5mg/L) and faecal bacterial concentrations, and are usually not suitable for irrigation or fish farming without tertiary treatment.
2. Assumes provision of sludge digesters

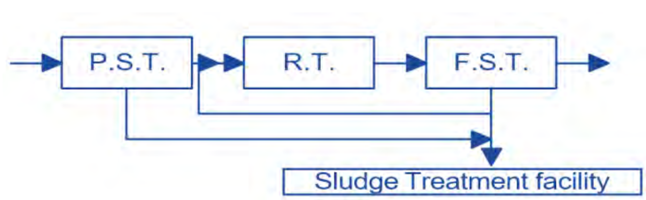
Treatment Process

Treatment Method	Composition of Treatment Process
Conventional Activated Sludge	
Oxidation Ditch	

Treatment Process

<u>**Treatment Method**</u>	<u>**Composition of Treatment Process**</u>
Stabilization Pond	
Aerated Lagoon	

Treatment Process

<u>**Treatment Method**</u>	<u>**Composition of Treatment Process**</u>
Trickling Filter	
UASB **(Up Flow Anaerobic Sludge Blanket)**	

Summary of Basic Conditions in South West Wastewater Treatment Plant

Items	Conditions
Target Year	2035
Service Area	Central Area (100.26 km^2)
Design Population	3,894,300 (Approx. 3.9 Million)
Design Flow (Daily Average)	▪ 790,000 m^3/d ▪ 323 ft^3/s
Effluent Sewage Quality (BOD_5)	50 mg/L (NEQS: Less than 80 mg/L)
Site Area	7,300 Kanal (304.3 ha) Land already acquired
Discharge of Treated Wastewater	Ravi River

Process of selecting best Wastewater Treatment Technology

Process — Select the process which can be Operated and Maintained locally

Land — Select the process according to Availability of Land

Effluent Quality — Select the process in which Effluent Quality meets design standards

Cost — Select the process which is least expensive (Capex & Opex)

Process of Selecting Best Wastewater Treatment Technology (Step 1 ~ Step 3)

Description	Activated Sludge	Oxidation Ditch	Aerated Lagoon	Trickling Filter	Waste Stabilization Pond	UASB
Step 1 : Processes	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Step 2: Land Availability	Already Available	Already Available	Already Available	Already Available	**Need to Acquire**	Already Available
Step 3: Effluent Quality	Meet the Standards	Meet the Standards	Meet the Standards	Meet the Standards	Meet the Standards	Meet the Standards

Process of selecting best Wastewater Treatment Technology
Step 4: Cost (Capex & Opex)

Unit: Million PKR

Description	Activated Sludge	Oxidation Ditch	Aerated Lagoon	Trickling Filter	Waste Stabilization Pond	UASB
Construction Cost (Capex)	16,998	12,239	8,499	11,389	14,397	15,128
Land Acquisition (Capex)	-	-	-	-	1,139	-
O&M Cost - Electricity (for 30 years) (Opex)	32,635	41,783	24,482	9,148	0	7,513
O&M Cost (Sludge Disposal) (for 30 years) (Opex)	2,487	1,872	3,010	2,654	2,180	1,351
Total Cost (Capex & Opex)	**52,120 (100%)**	**55,894 (107%)**	**35,991 (69%)**	**23,191 (44%)**	**17,716 (34%)**	**23,992 (46%)**

CONCLUSION

- Waste Stabilization Ponds is selected as best Wastewater Treatment Technology if Land is acquired.

- If Land is not acquired then Trickling Filter is selected as best Wastewater Treatment Technology

Note:

- **This comparison is for inflow of 790,000m^3/d with BOD of 250mg/l. Conclusion might be changed with different values of inflow & BOD.**
- **This comparison is conducted in Year 2010. Therefore conclusion might be changed now.**

BOD: Biochemical Oxygen Demand Test

How to Use

1. 

Pull out the line at the end of the tube

2. 

With the hole up, pinch the bottom half of the tube tightly with your finger and push out the air inside

BOD: Biochemical Oxygen Demand Test

3. 

Continue to place the hole in the test water, loosen the pinching fingers, and wait until half of the water is absorbed. Shake the tube gently 15 times to prevent leakage.

4. 

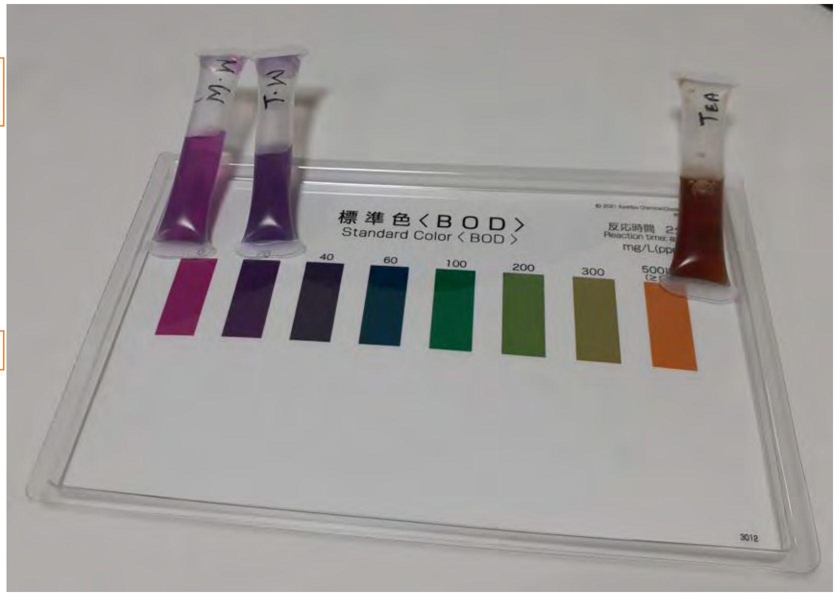
Immediately after 2 minutes, place the tube on top of the standard color and compare the colors.

BOD Test Results

Mineral Water (MW)

Tap Water (TP)

Tea



Quiz

Operation and Maintenance (O&M) of Sewerage System

Name of Trainee		Organization	
Total Marks	10	Obtained Marks	

——————

Short Answer Questions

1. **What are the reasons for cleaning sewer & manhole?**

____

____

____

2. **Enlist various tools and equipment, required for sewer cleaning?**

____

____

____

Fill in the Blanks

1. Hydrogen sulfide (H_2S) may attack ________________manholes (Concrete/ Plastic)
2. Pole mounted sewer camera is used to find _________________ connection. (cable / illegal)
3. Preventive maintenance can save the _______________. (time & money / nothing)

True/False

Sr. No.	Statement	Yes	No
1.	First stage of inspection is CCTV?		
2.	The maximum range of pole mounted sewer camera is 20 feet?		
3.	Is it necessary to ventilate the manhole before its cleaning?		

Measurement of Discharge in Drains

	Left	cm/s	Center	cm/s	Right	cm/s
	V1		V4		V7	
	V2		V5		V8	
	V3		V6		V9	
	Avg.		Avg.		Avg.	
Avg (cm/s)						
Avg (m/s)						
Avg Velocity (ft/s)						

	m	ft
Width		
Depth		

Q=A*V	

Name	
Designation	
Organization	
Total Marks	

ALJAZARI ACADEMY

SANITARY SEWER MANHOLE INSPECTION FORM		
M.H Depth: **From:**	**M.H #:**	**Date:**
I. Initial Inspection	**II. Structural Inspection**	**III. Hydraulic Inspection**
A. Location 1. Roadway ☐ 2. Gutter ☐ 3. Paved Alley ☐ 4. Unpaved Alley ☐ 5. Easement ☐ 6. Other ☐ **B.** Manhole Cover 1. Serviceable ☐ 2. Damaged ☐ 3. Displaced ☐ 4. Missing Grout ☐ 5. Needs Raising ☐ 6. Needs Lowering ☐ **C.** Ring & Frame 1. Serviceable ☐ 2. Damaged ☐ 3. Displaced ☐ 4. Missing Grout ☐ 5. Needs Raising ☐ 6. Needs Lowering ☐ **D.** Manhole Material 1. Brick ☐ 2. Concrete ☐ **E.** Size M.H Cover 1. 24 inch ☐ 2. 30 inch ☐ **F.** Manhole Size 1. 4 foot ☐ 2. 5 foot ☐	**A.** Steps 1. Serviceable ☐ 2. Unsafe ☐ 3. Missing (No.) ☐ 4. Corroded ☐ **B.** Cone 1. Serviceable ☐ 2. Broken ☐ 3. Leakage ☐ **C.** Riser 1. Serviceable ☐ 2. Broken ☐ 3. Leakage ☐ **D.** Shelf 1. Serviceable ☐ 2. Broken ☐ 3. Dirty ☐ 4. Bad Base Joint ☐ **E.** Channel 1. Serviceable ☐ 2. Obstructed ☐ 3. Bad Pipe Joint ☐ 4. Sit ☐ 5. Poor Structure ☐	**A.** Inflow Indication 1. Debris on Sides ☐ **B.** Surcharge Indicator 1. Greases / Debris on sides ☐ **C.** Clarity of Flow 1. Turbid Appearance ☐ 2. Clear Appearance ☐ **D.** Flow 1. Steady ☐ 2. Turbulent ☐ 3. Surcharging ☐ 4. Sluggish ☐ **E.** Flow Depth Compared to Adjacent Manhole 1. Same ☐ 2. Lower ☐ 3. Higher ☐ **IV. Vermin** 1. Roaches ☐ 2. Rats ☐ 3. Other ☐
Observation Summary:		

Annex 5.1.51 Training Material for "O&M of Mechanical and Electrical Equipment" in Fall (December) 2022

O&M of Electrical & Mechanical System

Pump, Motors, Motor Control units and Valves

By
Jawad Shahid
Vice Principal

Importance of Tube Well Pumps

This could be my home !

Importance of Disposal Station Pumps

This could be our children !

Topics to cover..

- ✓ Types of Pumps
- ✓ Pump operations
- ✓ Preventive maintenance of pumps
- ✓ Induction Motors
- ✓ Motor Control Units
- ✓ Valves and their Operation
- ✓ Asset Lifecycle Assessment
- ✓ Vibration Analysis
- ✓ Pump series and parallel op.
- ✓ Motor Starters,Pump Performance curve
- ✓ Preparation of Operational Plan
- ✓ Introduction to E-Learning Platform

Icebreaker and Class Introduction

Now it is your turn…

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

  WASA equipment?

Brainstorming

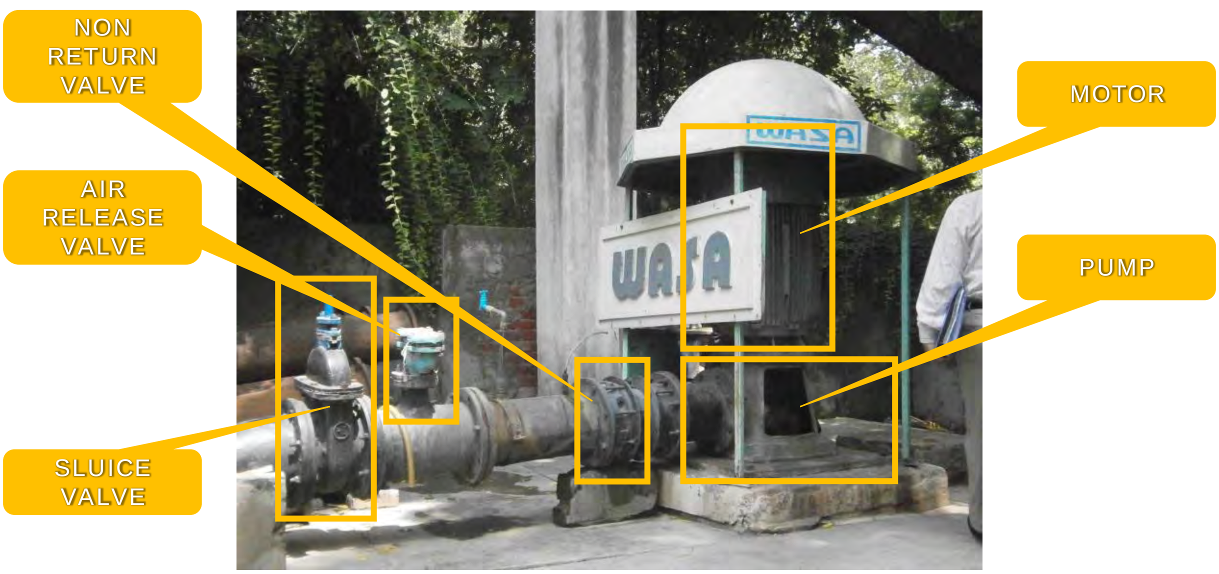
Now it is your turn…

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

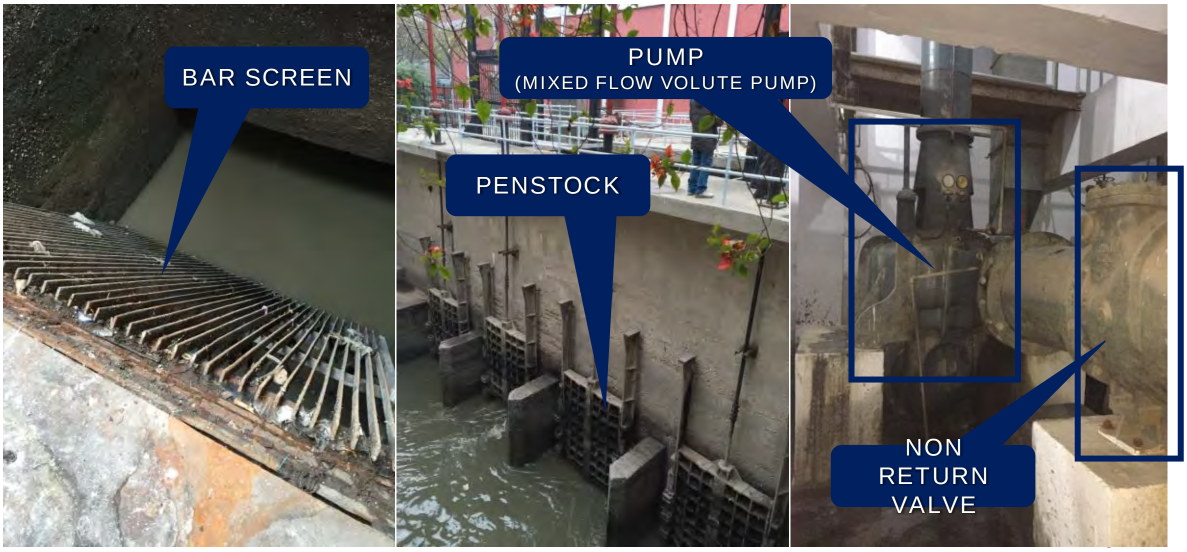
Resources and Handouts

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

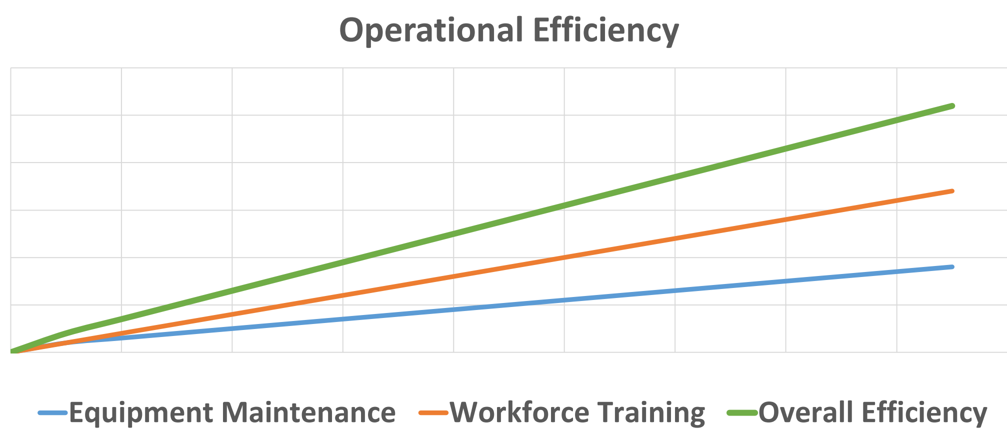
Introduction to Pumps (Tube Well)



Introduction to Pumps (Disposal Station)



Importance of Equipment Reliability and Trainings



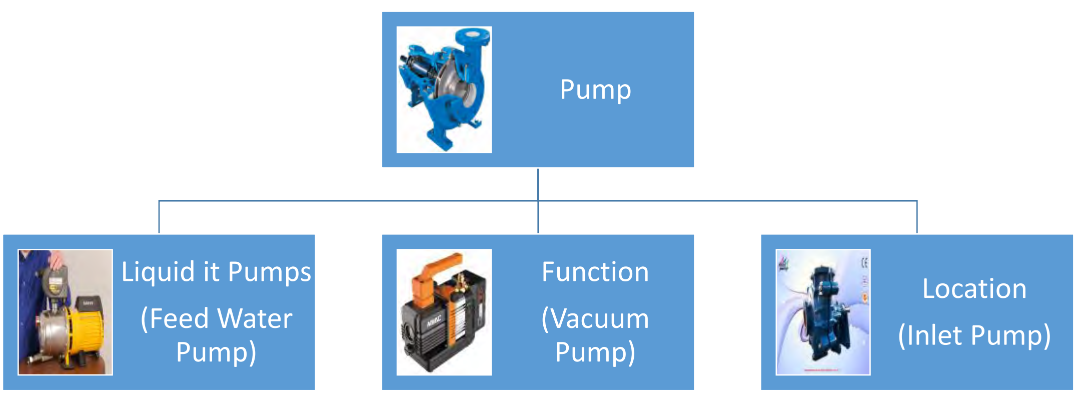
Introduction to Pumps

Pump

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



Identification of Pumps

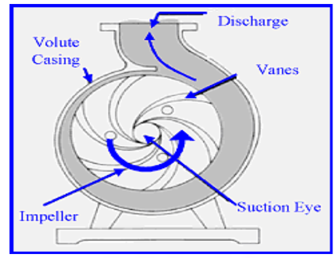


Introduction to Pumps

Two major categories:

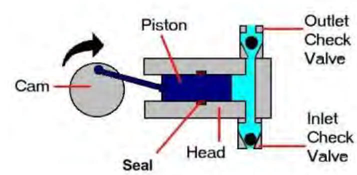
i) Centrifugal Pumps

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.

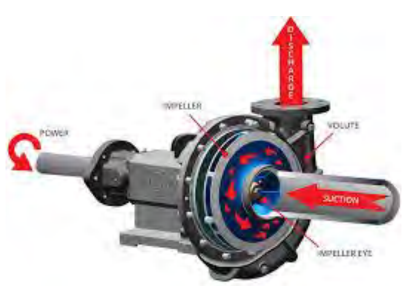


SINGLE ACTING RECIPROCATING

Introduction to Pumps

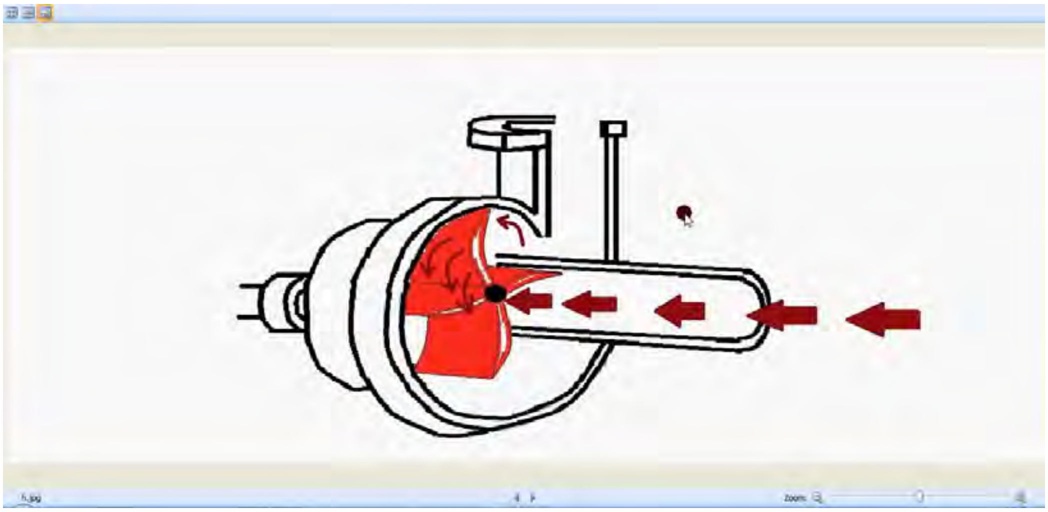
Centrifugal Pumps

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?

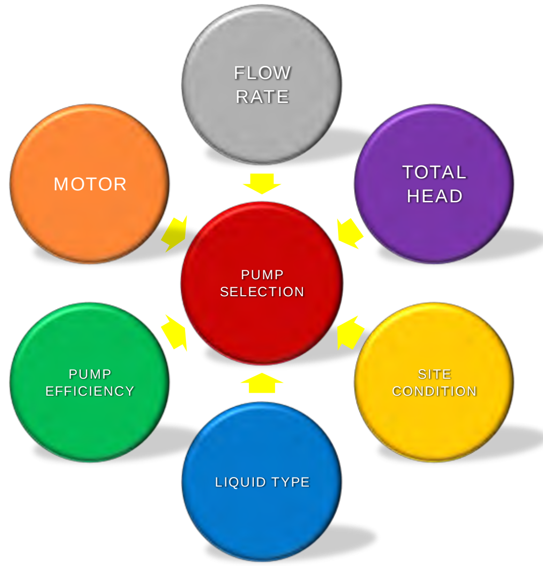
How far or high water will be delivered?

Is there a guaranteed pump efficiency need?

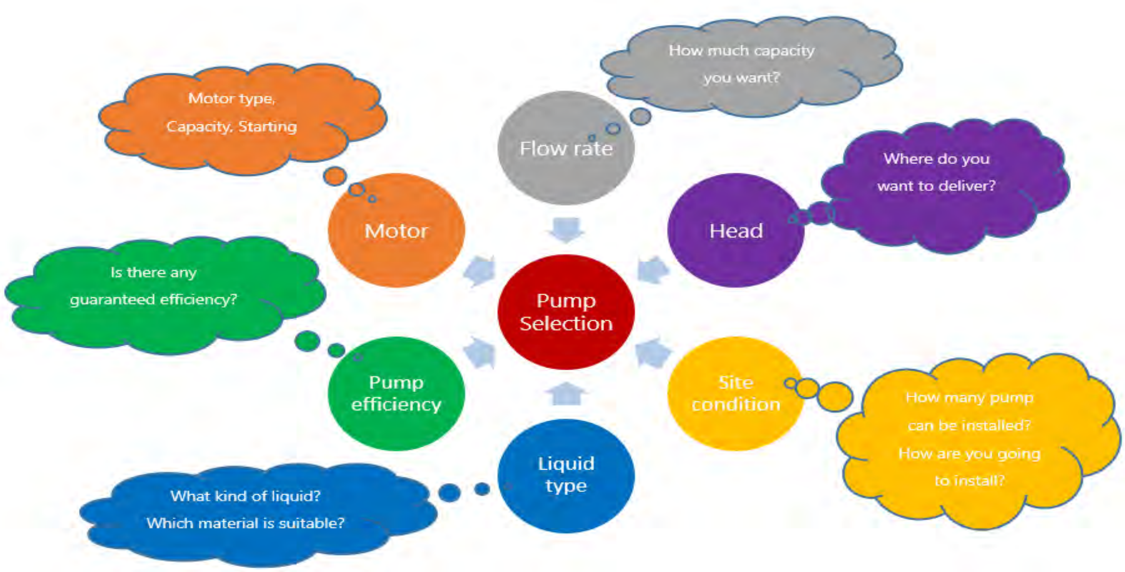
What kind of liquid is transported?

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

Centrifugal Pump Nameplate and Designation

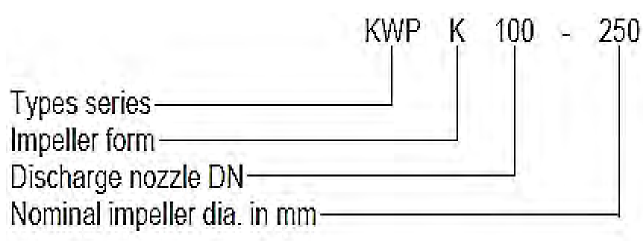
Specification:

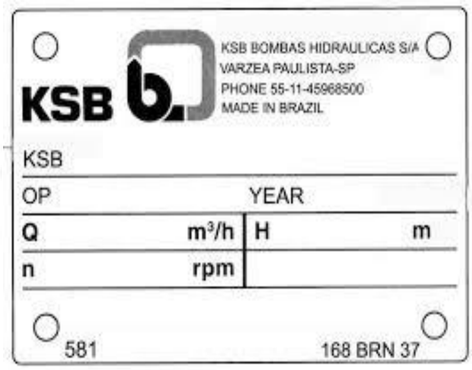
Discharge Diameter: 40--500mm(1.6--20inch)

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

Head: 6--80m

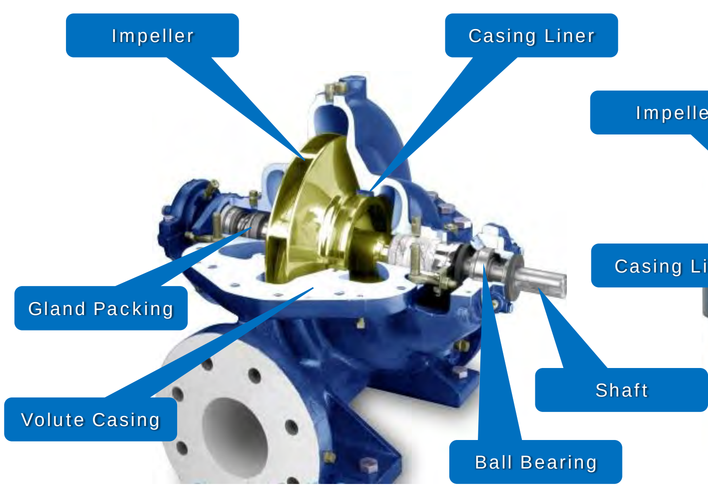
Name Plate and Designation



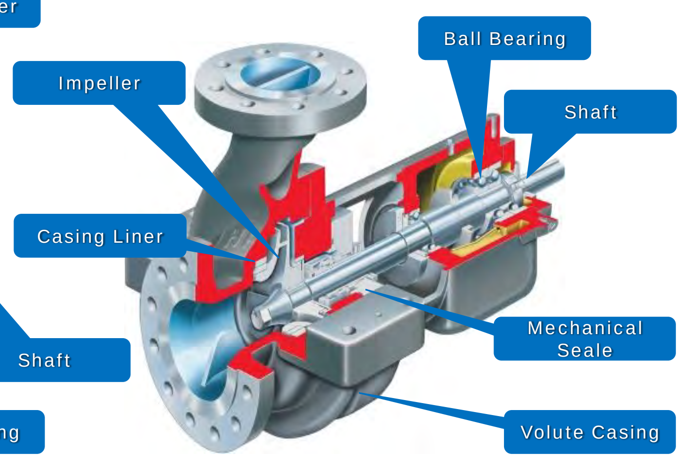


Assembly Parts of Pumps

Centrifugal Pump Structural Parts for Disposal Station



Double Suction Volute Pump



Single Suction Volute Pump

Assembly Parts of Pumps

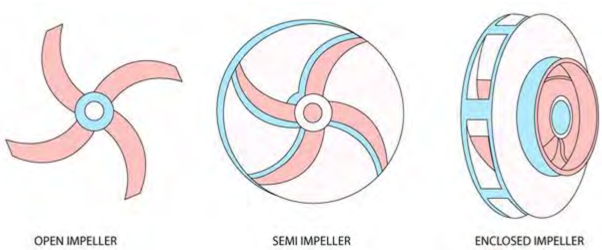
Submersible Pump Structural Parts for Disposal Station

Types of Impellers

Open Impeller
(Curved Blades)

Semi Closed

Closed Impeller
(Curved Blades)



Introduction to Pumps

Vertical Turbine Pump

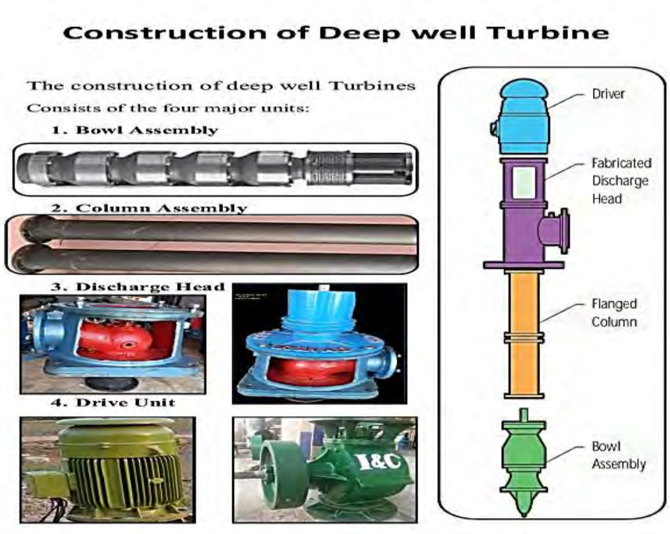
These pumps are commonly used in groundwater wells. These pumps are driven by a shaft rotated by a motor on the surface

Introduction to Pumps Types

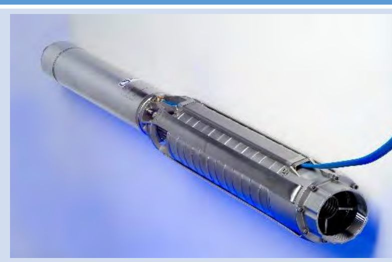
Submersible Pump

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

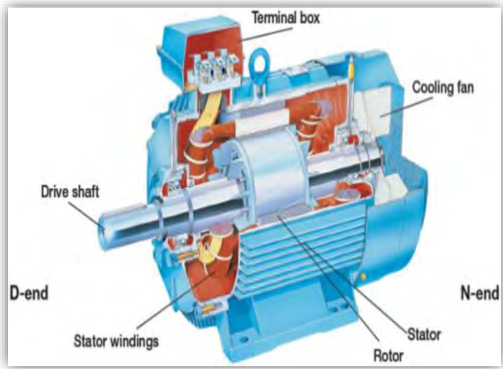


Comparison of Vertical pump and Submersible pump

	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

Introduction to 3 phase Induction Motors

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

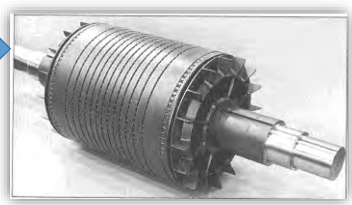


Basic Design and Construction

An induction motor has two main components:

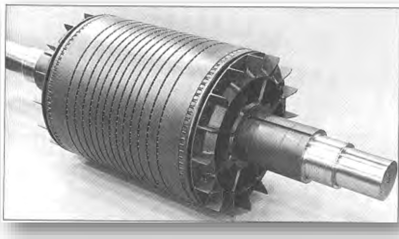
1. (Stationary part) Stator

2. (Revolving part) Rotor



Basic Design and Construction

Rotor Types

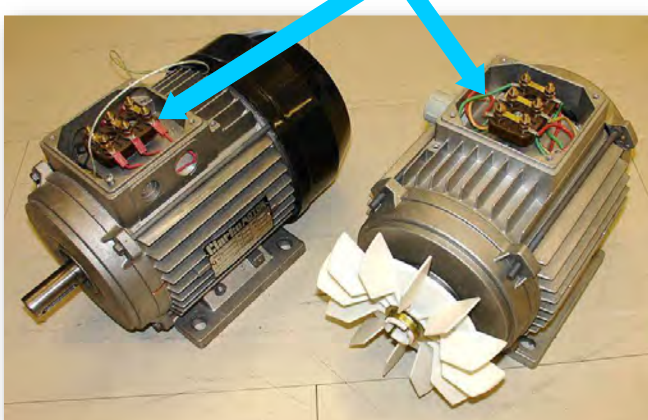


Squirrel cage rotor

Slip ring rotor

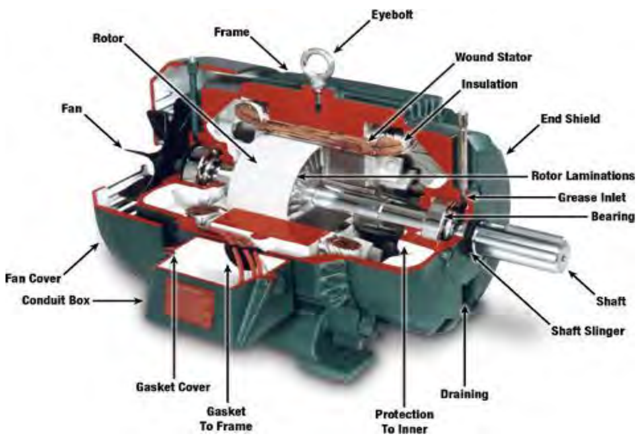
Basic Design and Construction

Terminals



Basic Design and Construction

Section View



Basic Design and Construction

Motor Burnout and Rewinding

Causes…

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

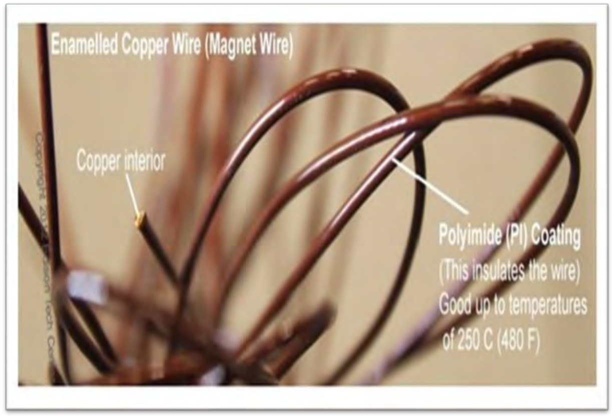
- Poor energy quality
- Load shedding
- Poor water quality
- High number of remedial maintenance operations
- Significant drop in static levels

Motor Burnout and Rewinding

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

Motor Burnout and Rewinding

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

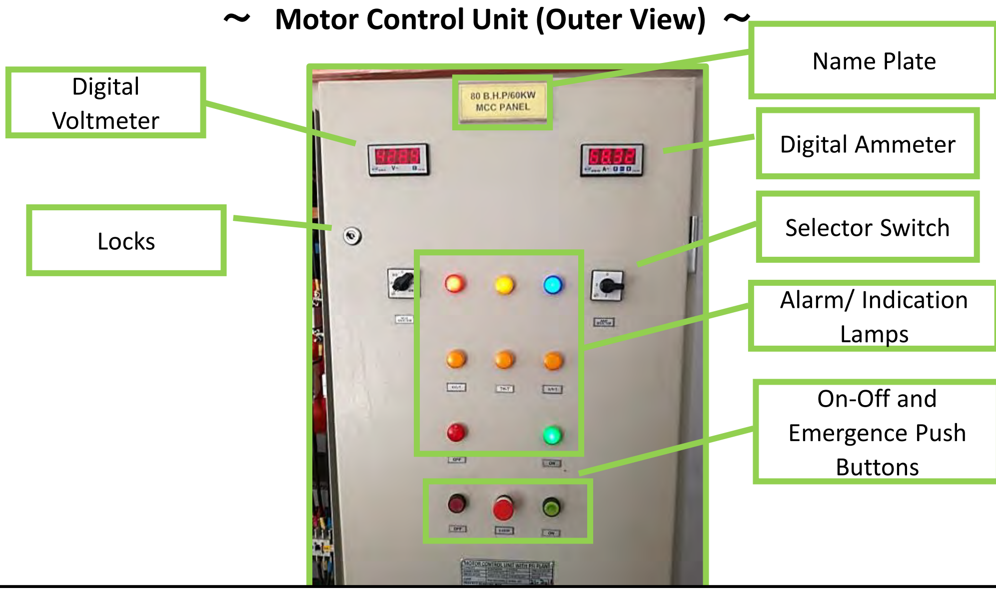


Introduction to Panel Components

What are these?

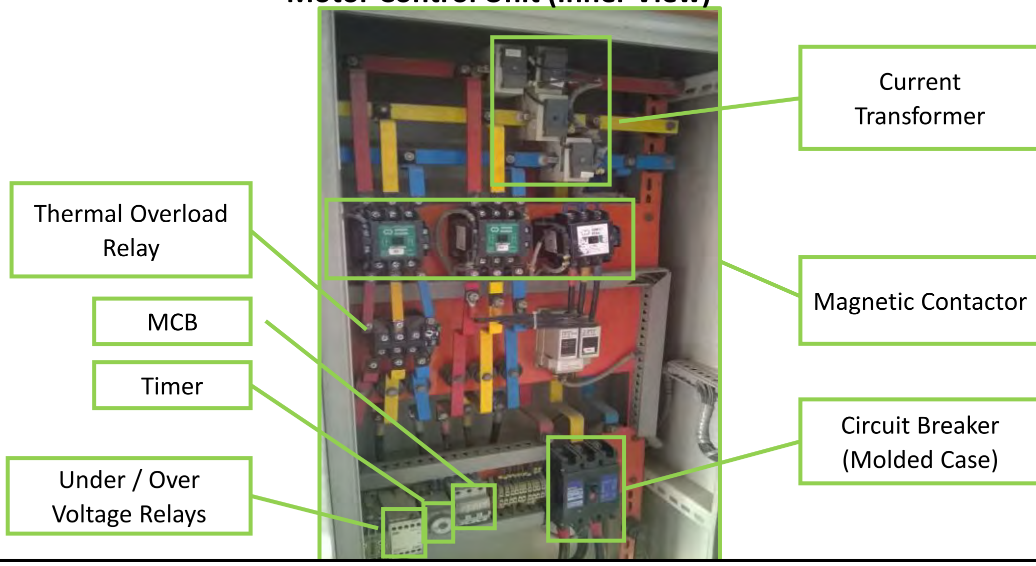
Components of Electrical Control Panel

~ Motor Control Unit (Outer View) ~



Components of Electrical Control Panel

~ Motor Control Unit (Inner View) ~

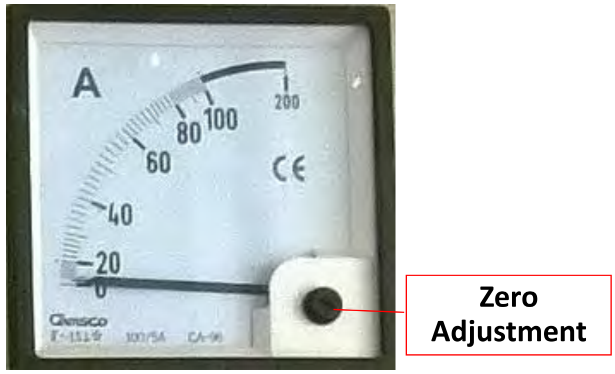


Selector Switches

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

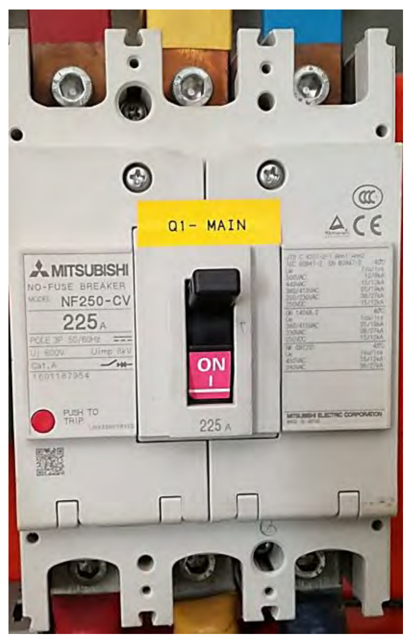
Ampere & Voltmeter meter

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



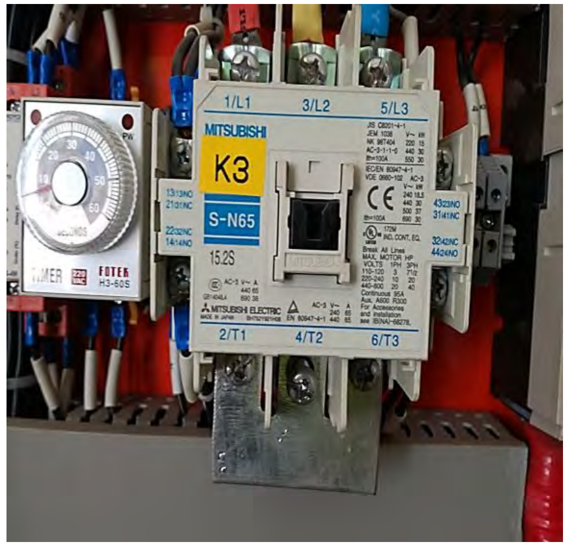
1. Circuit Breakers

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



2. Contactor

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



Protective Relays

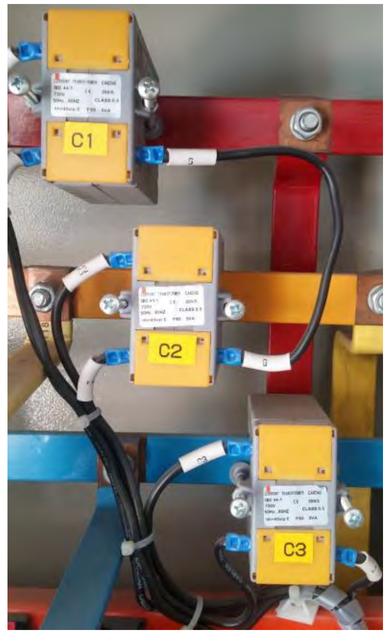
- ✓ Protective relays detect electrical faults, isolate the faults from system and activate alarms is a faulty condition sensed

Thermal Relay

Under/Over Voltage Relay

Phase Failure Relay

5. Current transformers (CT)



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

6. Timer

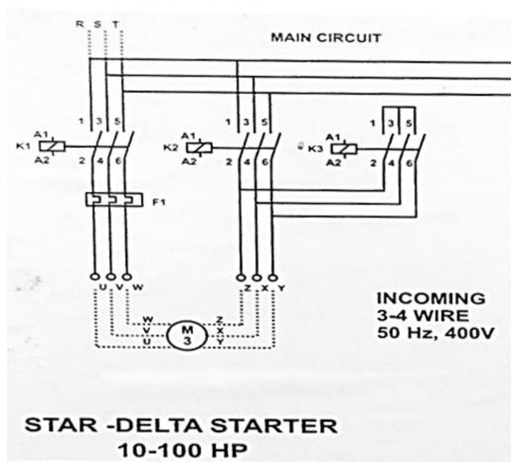
- ✓ Use to convert the motor connections from Star to Delta after specific time

WIRING DIAGRAMS

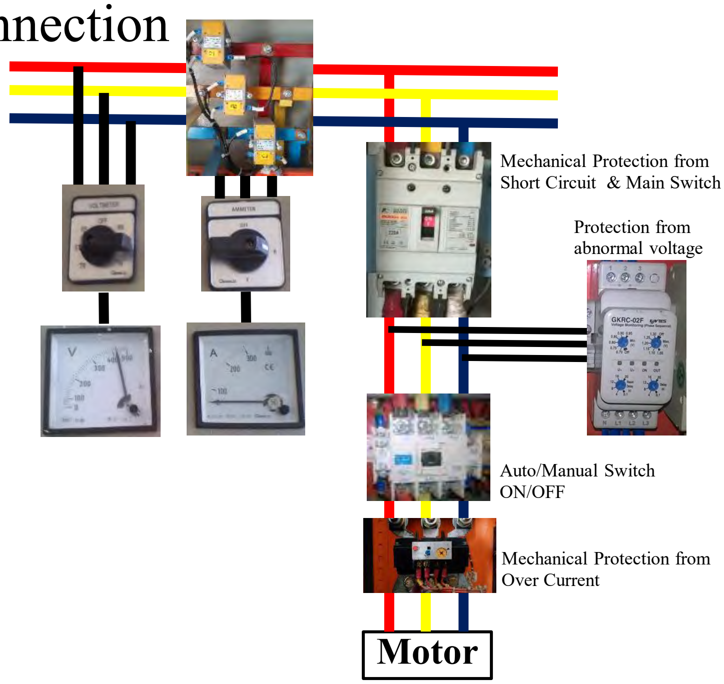
Wiring Diagram

✓ Shows how the components are connected

✓ It should be always available at the site



Basic Concept of Connection



Basic Power Circuit for Motor

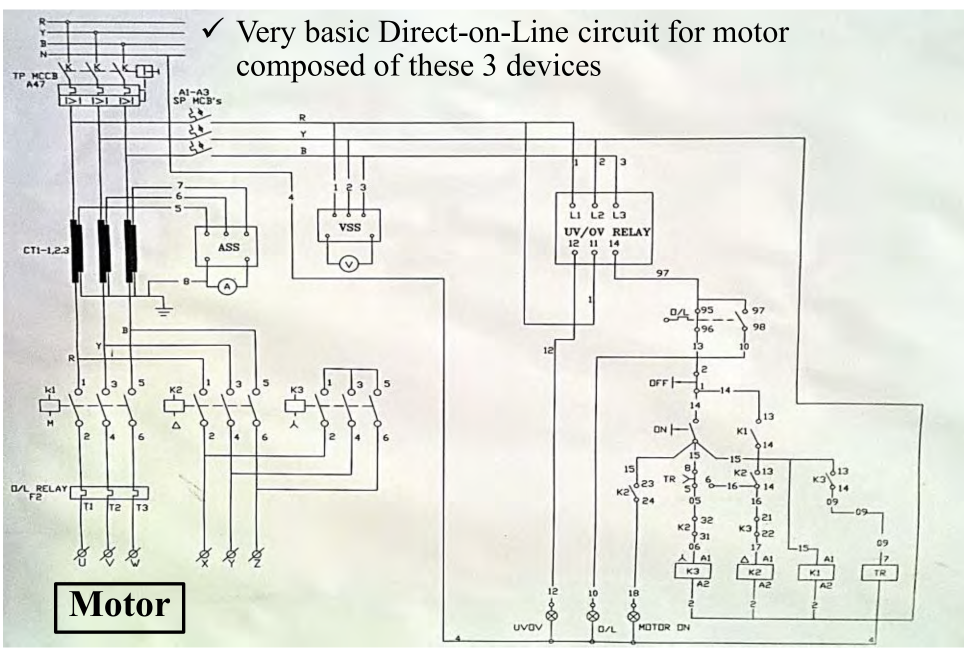
- Circuit Breaker
- Magnetic Contactor
- Over Load/Thermal Relay
- Over/Under Voltage Relay

Monitoring Device

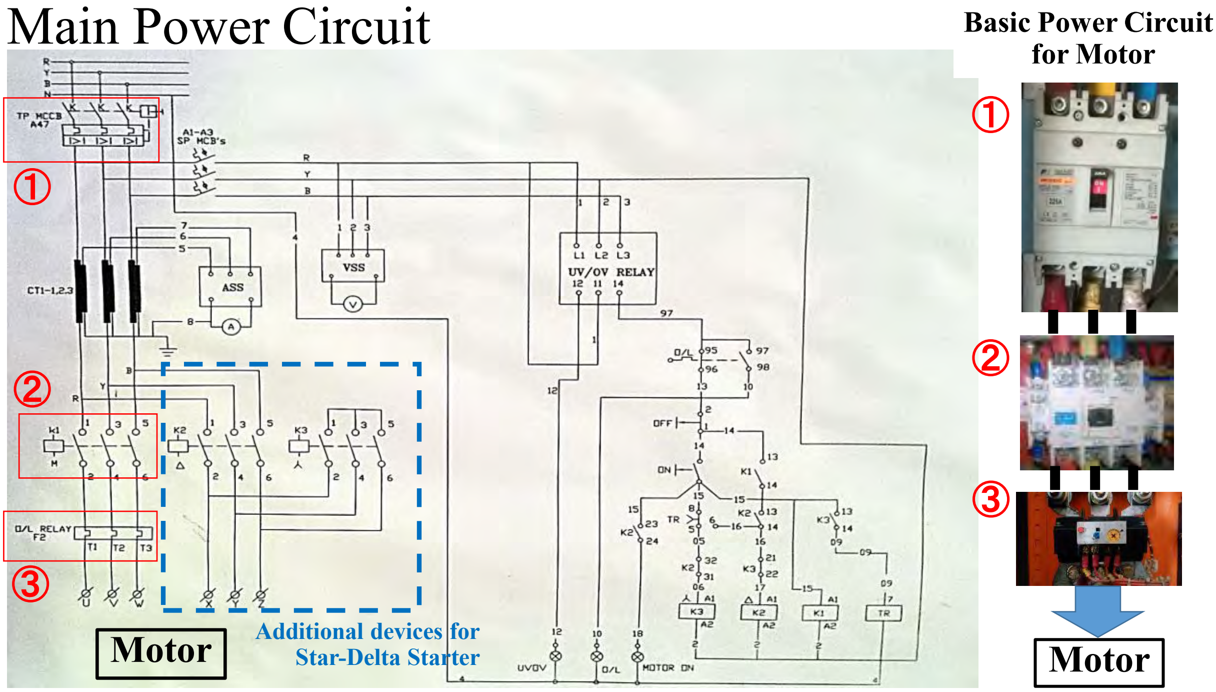
- Voltage Meter
- Ampere Meter

Main Power Circuit

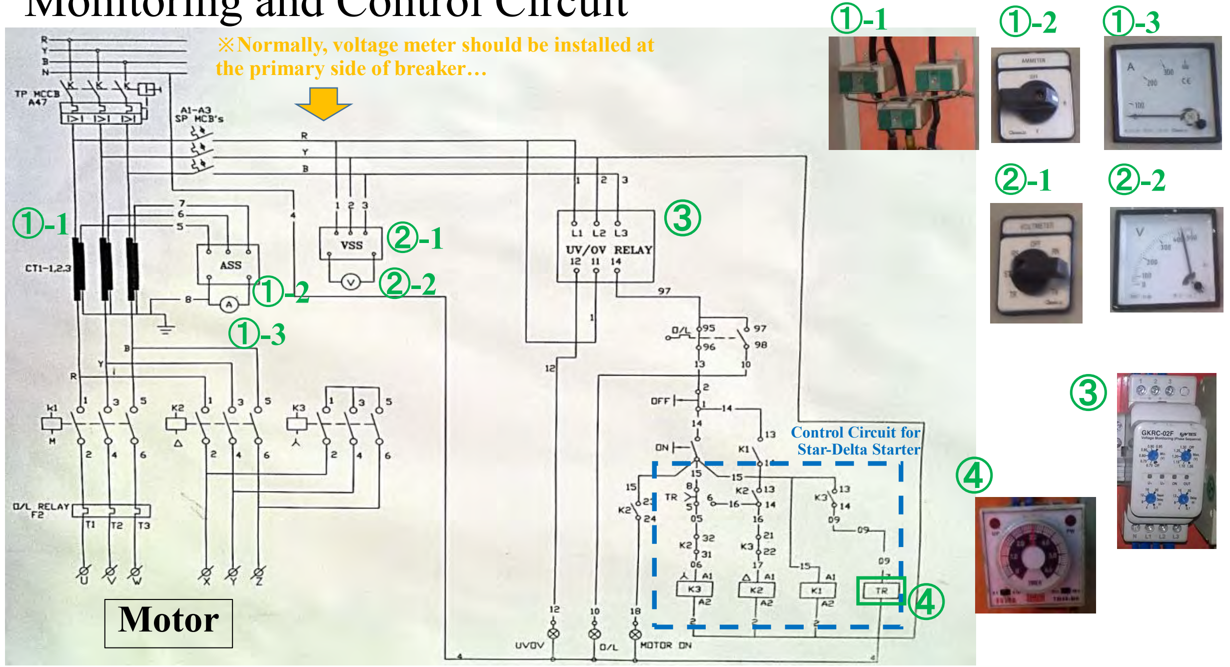
✓ Very basic Direct-on-Line circuit for motor composed of these 3 devices



Main Power Circuit



Monitoring and Control Circuit



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 process pressure.
- ✓ Relieving component or piping pressure.

Introduction and selection of valves

Classification of Valves

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

Linear Motion Valves.

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

Introduction and selection of valves

Classification of Valves

Rotary Motion Valves.

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

Quarter Turn Valves.

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

Introduction and selection of valves

Classification of valves based on motion

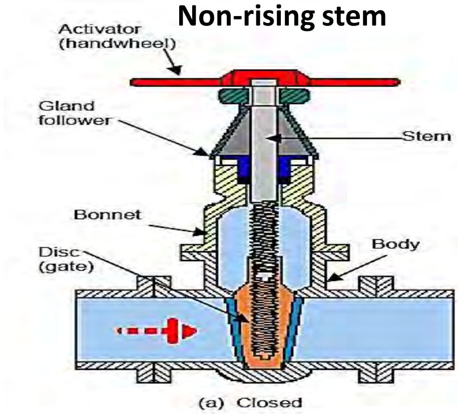
Valve types	Linear motion	Rotary motion	Quarter turn
Gate Valve	x		
Air release valve	x		
Butterfly valve		x	x
Non-return valve		x	x
Flap valve		x	

Assembly parts of valves

Basic Parts of the valve

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

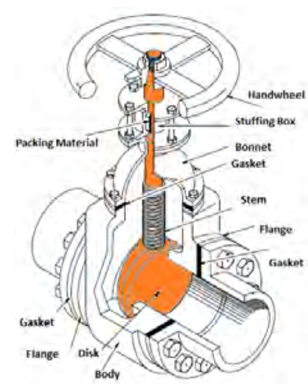
Non-rising stem



Introduction and selection of valves

Methods of controlling flow through a valve.

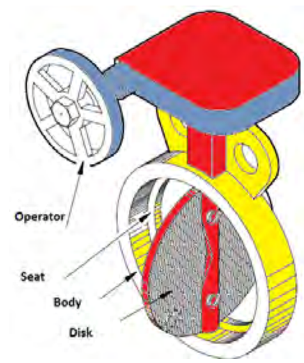
1. Slide a flat, cylindrical, or spherical surface across the orifice.



Gate valve

Introduction and selection of valves

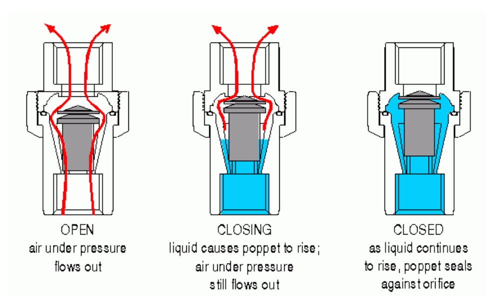
2. Rotate a disc or ellipse about a shaft extending across the diameter of an orifice.



Butterfly valve

Introduction and selection of valves

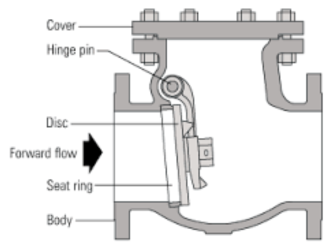
3. Ball linearly moves upwards to close of an orifice.



Air release valve

Introduction and selection of valves

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

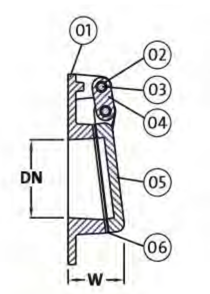


Non return valve

Introduction and selection of valves

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

Insulation Testing for 3-Phase Motor

What is "Insulation Resistance" ?

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

Insulation Resistance Tester

Analysis and Testing Equipment

Step By Step Procedure for Insulation Testing

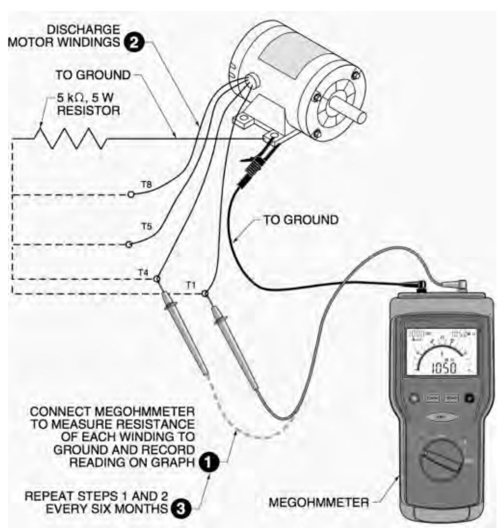
1. Connect the terminals of insulation tester black with earth and red with U_1, V_1 and W_1 one by one with energize insulation tester and note values.
2. Cross winding insulation test

   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.



Sample Format for Preventive Maintenance

Preventive Maintenance Sheet for Electrical Facility

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

① Test in OFF Condition

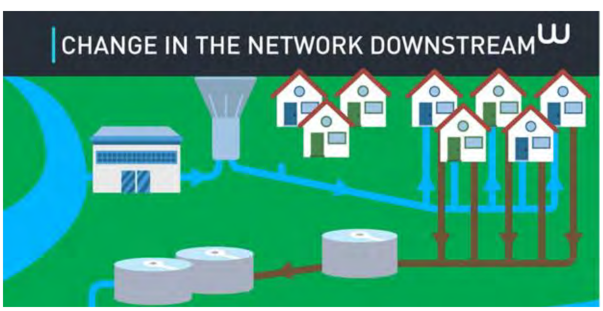
② Test in Running Condition

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

Issues in Pumps

Trouble shooting Pumps

1. Corrosion
2. Cavitation
3. Change in Flow and Pressure



Issues in Pumps

Trouble shooting Pumps

1. Corrosion
2. Cavitation
3. Change in Flow and Pressure

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).

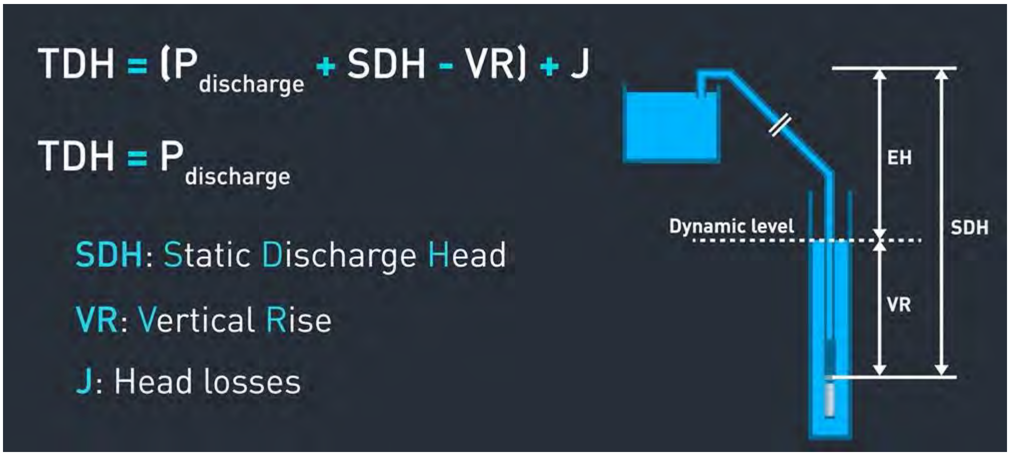
Troubleshooting

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).

Imersed Tubewell Pump

Total Dynamic head



Thank you

Engr. Jawad Shahid

ELECTRICITY to WATER

Introduction to Advanced Energy Audit in Water Supply

By
Jawad Shahid
Vice Principal

Importance of Tube Well Pumps

This could be my home !

Topics to cover..

- Introduction and Importance of Advanced Energy Audit
- Hands on Activity, wiring of MCU
- Energy Audit of miniature Pumping Station
- Use of Electro-Mechanical Equipment
- Data Extraction from Power Analyzer and Ultra-Sonic Flow Meter

Topics to cover..

- Energy Assessment Tool
- Actual Issues faced by WASAs Durin Energy Audit
- Explanation of Q-H curve
- Series and Parallel Pump Operation
- Preparation of Energy Development Plan

Icebreaker and Class Introduction

Now it is your turn…

- Degree and backgrounds?
- Share your work experience relati

  WASA equipment?

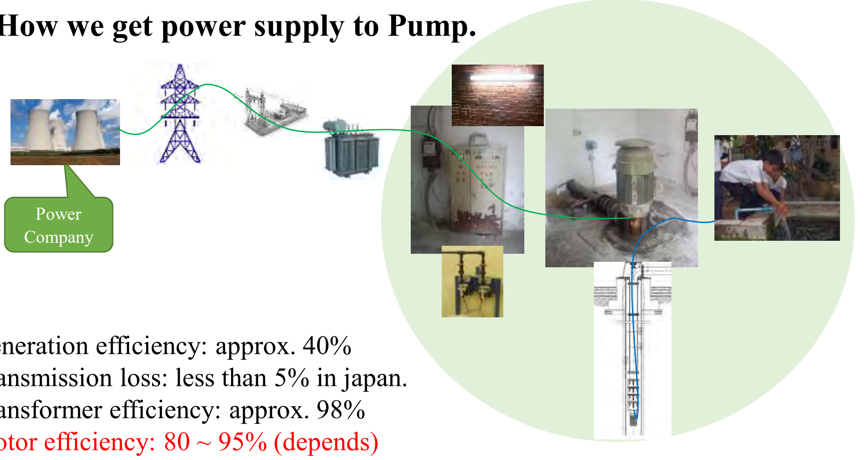
Brainstorming

Now it is your turn…

- Any prior experience of Energy?
- Why interested in this Energy Audit ?
- What best skills do you bring to the class?

ELECTRICITY to WATER

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



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

WHAT IS ENERGY AUDIT ACTIVITY

ELECTRICITY to WATER

Energy Audit: An Energy Audit is an assessment and analysis of Energy Flows in a process, aimed at reducing the amount of energy input into the system without negatively affecting the outputs.

Objective Audit: The main objective of an energy audit is to explore various possibilities for energy conversation.

Approach: An Energy Audit requires a through and detailed study of a system, through the performance of various tests and measurements.

BASIC KNOWLEDGE for ENERGY AUDIT

Concept of

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

ELECTRICITY to WATER

Levels of Assessment

- Level I Assessment – Preliminary Energy Use Analysis & Walk Through Analysis; simple assessment based on available documents and information, physical inspection, and staff interviews to create a baseline and identify obvious energy efficiency measures which are easy to implement
- Level II Assessment – Energy Survey and Analysis; review of data, existing and newly gathered, to identify all energy saving measures and identify high potential measures for further investigation
- Level III Assessment – Detailed Analysis of Capital Intensive Measures; also known as Investment Grade Audit used to give a detailed assessment of costs and benefits derived from capital intensive energy conservation measures

ELECTRICITY to WATER

Steps in an Energy Audit

- Collect and analyze historical energy usage.
- Study pumping systems and their operational characteristics.
- Identify potential modifications that will reduce the energy usage and/or cost.
- Perform an engineering and economic analysis of potential modifications.
- Prepare a rank-ordered list of appropriate modifications.
- Prepare a report to document the analysis process and results.

ELECTRICITY to WATER

Levels of Assessment

- Level I Assessment – Preliminary Energy Use Analysis & Walk Through Analysis; simple assessment based on available documents and information, physical inspection, and staff interviews to create a baseline and identify obvious energy efficiency measures which are easy to implement
- Level II Assessment – Energy Survey and Analysis; review of data, existing and newly gathered, to identify all energy saving measures and identify high potential measures for further investigation
- Level III Assessment – Detailed Analysis of Capital Intensive Measures; also known as Investment Grade Audit used to give a detailed assessment of costs and benefits derived from capital intensive energy conservation measures

ELECTRICITY to WATER

Level I Assessment

- Purpose for undertaking:
  - Gain a full understanding of how energy is being consumed and the associated costs
  - Report on energy use to internal or external stakeholders
  - Find energy conservation programs for immediate and future consideration
  - Identify projects for future energy reduction
  - Set targets for energy reduction
- Results:
  - Baseline of energy use
  - Forecast of future energy use based on current / historical consumption
  - Identification of no/low cost measures for energy reduction
  - List of potential projects for future investigation
  - Detailed benchmarking for accurate comparison to other facilities and own past performance
  - Preparation for next level of assessment

ELECTRICITY to WATER

Level II Assessment

- Purpose for undertaking:
  - Desire to take advantage of energy and cost savings from a wider range of projects
  - Creation of a full energy conservation program
- Results:
  - Evaluation of all potential energy conserving operational changes and capital investments available
  - Listing of capital projects that require further investigation prior to implementation
  - Preparation for next level of assessment

ELECTRICITY to WATER

Level III Assessment

- Purpose for undertaking:
  - Desire to undertake significant capital projects to improve energy efficiency based on projects identified in previous levels of assessment
  - May include gaining access to external financing under performance contract.
- Results:
  - Detailed information provided so that owners have a high level of confidence in decision making regarding significant capital investment
  - May include implementation of capital intensive EE measures under performance contract.

ELECTRICITY to WATER

Method & Approach for Water Systems

- The audit involves carrying out various measurements and analysis of the following systems to assess losses and the potential for energy efficiency improvements:
  - Pumps & Pumping Systems
  - Electrical Systems
  - Electric Drives

ELECTRICITY to WATER

Measurement

- Data collection
  - Specifications of pumps and motors
  - Diagram of water distribution air network
  - Water pressure required for the system
  - Number of pumps in operation
  - Design/specified water temperature required
- Water flow rate of pumps at various operating conditions
  - Individual
  - Parallel
- Water flow velocity in pipe lines
- Suction & discharge pressure of pump

ELECTRICITY to WATER

Data Analysis and Energy Conservation Measures (ECMs)

- Full written description of each ECM to include:
  - Existing conditions and data collection approach (snapshot, short-term, or long-term measurement of data)
  - Recommendations. Include discussion of facility operations and maintenance procedures that will be affected by ECM installation and implementation.
- Baseline energy use:
  - Summary of all utility bills
  - Base year consumption and description of how established

ELECTRICITY to WATER

Data Analysis and Energy Conservation Measures (ECMs)

- Savings Calculations:
  - Base year energy use and cost
  - Post-retrofit energy use and cost
  - Savings estimates including analysis methodology, supporting calculations, and assumptions used
  - Operations and maintenance savings
  - If manual calculations are employed, formulas, assumptions, and key data shall be stated.

ELECTRICITY to WATER

Data Analysis and Energy Conservation Measures (ECMs)

- Cost Estimate:
  - Engineering/design costs
  - Contractor/vendor estimates for labor, materials, equipment; etc
  - Construction management fees
  - Commissioning costs
  - Other costs/fees

ELECTRICITY to WATER

Energy Audit Report Format

- Executive Summary
- Background
- Energy Scenario
- Inventories
- Baseline Parameters & Adjustments
- System Mapping Details
- List of Potential Energy Saving Projects
- Detailed Financial Analysis (Payback, NPV, IRR)
- Details of Approved Projects
- M&V Plan
- Risk Assessments & Mitigation Plan
- Annexure

Responsibility Matrix

S.No.	Designation	Responsibility
1.	Director	Approve and Present
2.	Executive Engineer	Verify and Prepare Recommendations for Improvement
3.	Sub-Divisional Officer	Supervise Energy Audit
4.	Sub-Engineer / Supervisor	Perform Energy Audit

Equipment Required for Energy Audit

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

Power Analyzer:

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

BASIC KNOWLEDGE for ENERGY AUDIT

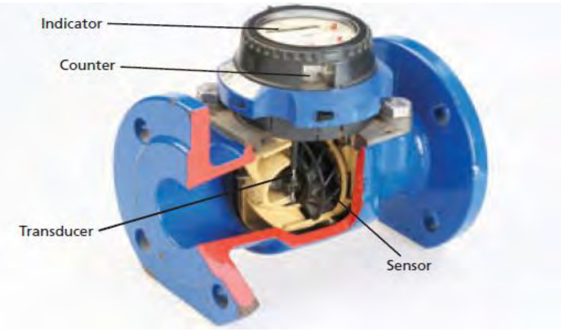
✓Turbine Meters

✓Ultra Sonic Flow Meters

✓Electromagnetic Meters

Turbine meter

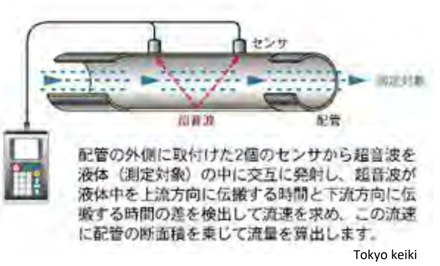
- ✓These meters have a rotating element that turns with the flow of water.
- ✓Volume of water is measured by the number of revolutions by the rotor.



Ultrasonic meters

- ✓Sending sound waves from 2 sensor (transmitter) diagonally across the flow of water in the pipe.
- ✓The time difference between 2 direction to be converted to flow velocity.

(there is Doppler shift method, too)



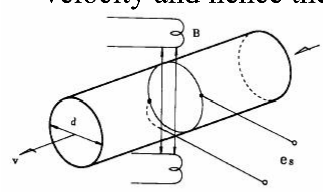
Tokyo keiki

Ultrasonic flowmeter (time transit)

Electromagnetic meter

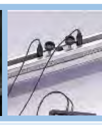
✓Induce magnetic field in the bore by coils outside of the flow channel. When water flows the magnetic field, electromotive force (Voltage) is induced.

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



Electromagnetic flowmeter

BASIC KNOWLEDGE for ENERGY AUDIT

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

BASIC KNOWLEDGE for ENERGY AUDIT

Principles of Measurement

Pressure measurement

Ultrasonic Flow meter:

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

Pressure Gauge

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

Water level meter

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

Tachometer

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

Digital Thermometer

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

Vibration meter

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

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

Pump Data | Motor Data

Date(yyyy-mm-dd): - -

Time(in 24 hour scale) :

Location:

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

Diameter of Discharge Pipe (m)

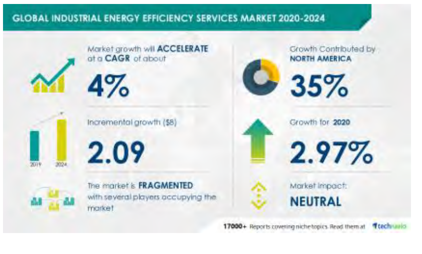
Sr. #	Parameter	Unit	Method	Figure	Criteria for TW WASA Lahore
1	Discharge Pressure (p_d)	bar	Pressure Gauge		> 2 (WASA standard)
2	Flow (Q)	m³/h	Ultrasonic Flow meter		To Be -20% to +10% of Design Flow
3	Dynamic Water Level (hpl)	m	Level Meter		according to design
4	Static Water Level (hpl)	m	Level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

FINDINGS & RECOMMENDATIONS

Surveyer: Attendance:

Development of Energy Management Plan

- Introduction
- Installed Capacity
- Calculations
- Analyzing and Implementing Findings
- Electric Utility Billing Structures
- Energy Benchmarking
- Energy Efficiency improvement Measures
- Implementing Findings



Energy Assessment Tool

EQUIPMENT ELECTRICAL ENERGY INVENTORY

System Type	Equipment Type	Equipment Description	Motor Size (hp)	Motor Efficiency (%)	Motor Full Load Amperage (FLA)	Average Motor Operating Current (Amps)	Operating Hours (Hrs/Yr)	Average Load Factor (%)	Average Electric Load (kW)	Estimated Annual Energy Use (kWh/yr)	Estimated Annual Operating Costs ($/Yr)	Estimated Percent of Site Electric Use & Cost (%)
Lighting	Other kW Load	All Site Lighting	N/A	N/A	N/A	N/A	8,760	100.00%	12.77	111,865	$11,321	4.98%
Non Process HVAC	Other kW Load	All Site HVAC	N/A	N/A	N/A	N/A	8,760	100.00%	7.36	64,474	$6,525	2.87%
Influent Pumping	Pump	Infl Pump Station	25	89.0 %	20	17	4,700	85.00%	18.01	84,667	$8,568	3.77%
Primary Treatment	Blower	Grit Blowers	7.5	89.0 %	8	5.5	8,760	68.75%	4.32	37,861	$3,831	1.68%
Primary Treatment	Blower	Channel Blower	10	88.0 %	10.5	6.8	8,760	64.76%	5.49	48,093	$4,867	2.14%
Secondary Treatment	Blower	Secondy Blowers	200	91.0 %	225	185	8,760	82.22%	134.81	1,180,921	$119,509	52.53%
Secondary Treatment	Blower	Secondy Blowers	200	91.0 %	225	185	450	82.22%	134.81	60,664	$6,139	2.70%
Secondary Treatment	Pump	WAS Pumps	7.5	86.0 %	8	4	1,460	50.00%	3.25	4,749	$481	0.21%
Fixed Film Treatment	Pump	R.Tower Pumps	60	91.0 %	65	36	8,760	55.38%	27.24	238,639	$24,150	10.62%
Anaerobic Digestion	Pump	Sludge Recir Pump	5	85.0 %	6	5	8,760	83.33%	3.66	32,034	$3,242	1.43%
Anaerobic Digestion	Mixer	Gas Mixer	10	88.0 %	12	9	8,760	75.00%	6.36	55,696	$5,636	2.48%
Anaerobic Digestion	Other kW Load	Mixer Heater	N/A	N/A	N/A	N/A	2,500	100.00%	7.20	18,000	$1,822	0.80%
Effluent Pumping/Storag	Pump	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Contact:

Engr. Jawad Shahid

Advanced Energy Audit

By
Jawad Shahid
(Vice Principal)

The Urban Unit

ALJAZARI ACADEMY

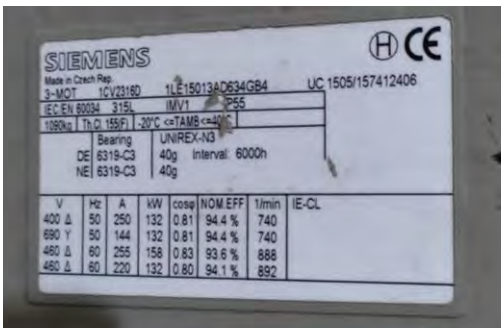
JICA

Basic O&M of Pumping Machinery

- Energy Audit:
- Purpose: In order to evaluate the pumping efficiency and monitor changes over time

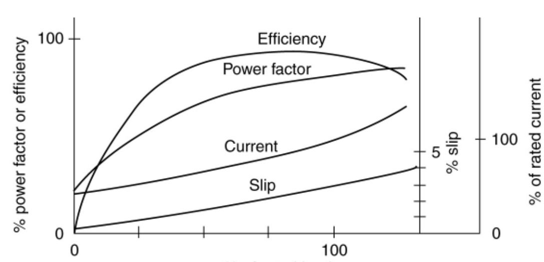
Causes of Low Power Factor For Induction Motor

- What Could be the reason for low Power Factor in 3 Phase Induction Motors?



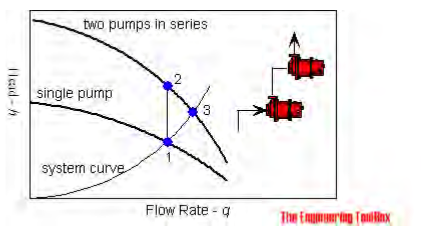
Causes of Low Power Factor For Induction Motor

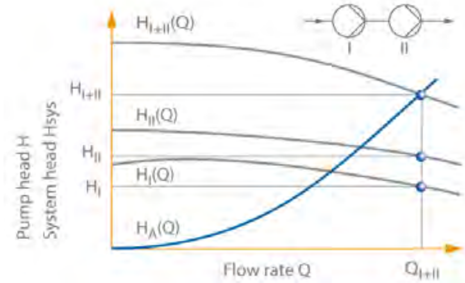
- For Induction motors, the pf is usually extremely low (0.2 - 0.3) at light loading conditions and it is 0.8 to 0.9 at full load.
- In some cases, due to improper wiring or electrical accidents, a condition known as 3-φ power imbalance occurs. This results in low power factor too.



Series Pump operation

- When two centrifugal pumps (I and II) are operating in series, the head (HI+II) is the sum of the individual pumps' heads and the flow rate remains the same.

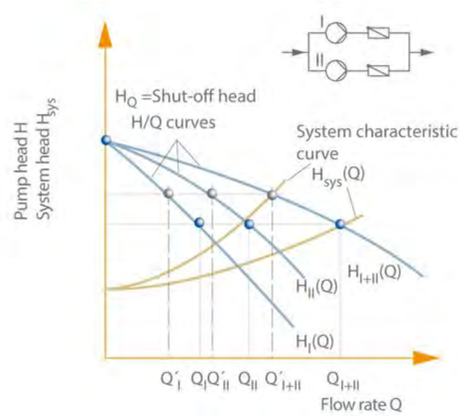




Series operation: Series operation of two centrifugal pumps I and II with any type of characteristic curves

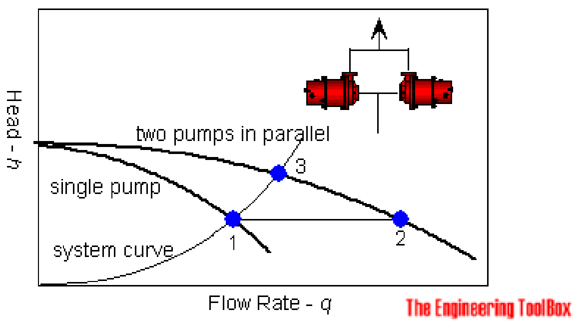
Parallel Pump Operation

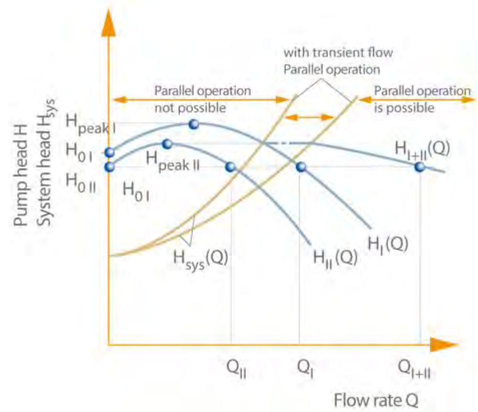
- If two centrifugal pumps I and II are operated in parallel, the flow rate QI+II is the sum of the flow rates of the individual pumps at the same head, i.e.:



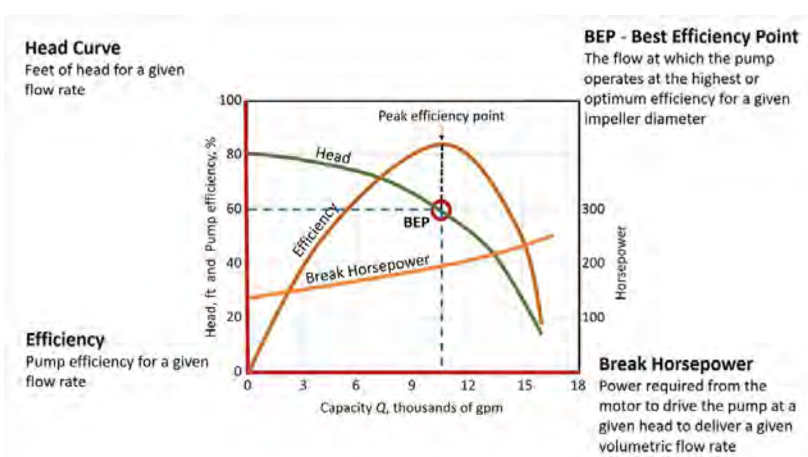
Parallel operation: Two centrifugal pumps I and II with stable characteristic curves

Parallel Pump Operation

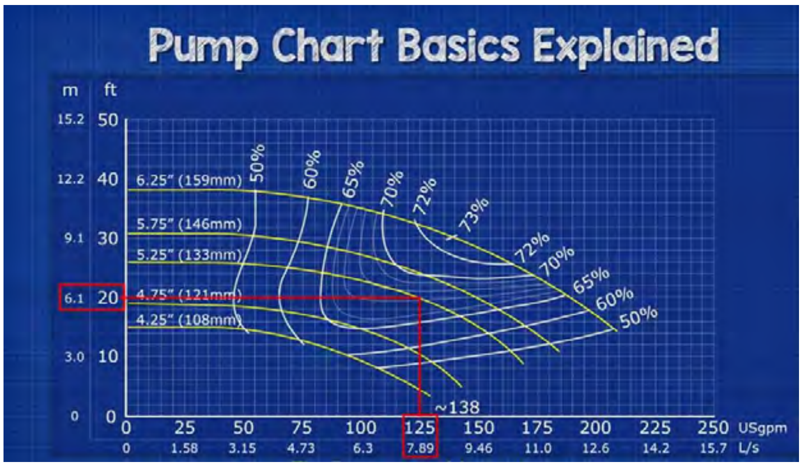




Q-H Curve



Pump Efficiency



Flow and current relationship

- With Increase in flow, pressure will decrease and power consumption will increase
- With Decrease in flow, pressure will increase and power consumption decreases.

Effect of over sizing and under sizing the motor on power consumption

- Undersize:
  - Overload
  - Lower Flow
  - Higher Power Consumption

- Oversize:
  - Underutilization
  - V. Low Power Factor
  - Energy Wastage

Selecting the wrong size motor

- What are the power demands of the pump?

- What will typical operation look like for this pump?

- Will the pump be operated on a variable frequency drive (VFD)?

Facility Failure Analysis

By

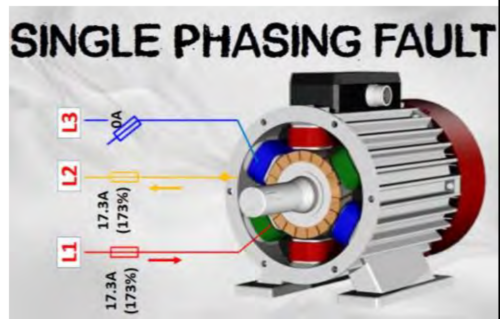
Jawad Shahid

1. What happens if shaft of a pump breaks during operation for a vertical turbine pump for Disposal Station

Explanation:

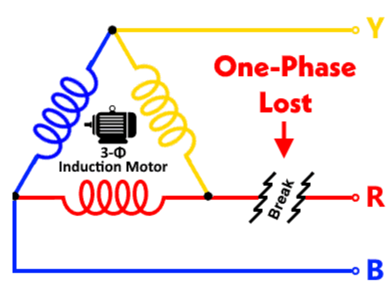
2. What happens if one phase of power supply fails during operation of Pump and Motor, explain in a step-wise approach.

Condition 1: With protective relays installed and calibrated.



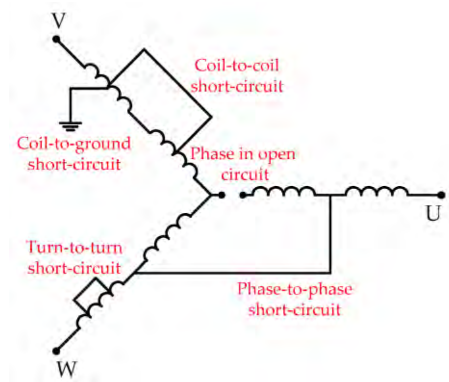
2. What happens if one phase of power supply fails during operation of Pump and Motor, explain in a step-wise approach.

Condition 2: All protective relays by-passed.



3. What happens if during operation of a tube-well two windings of a motor short circuit (Motor Burnout).

Condition 1: Protective relays installed and calibrated.



3. What happens if during operation of a tube-well two windings of a motor short circuit (Motor Burnout).

Condition 2: Protective relays by-passed

4. Shaft of a vertical turbine tube-well breaks during operation.

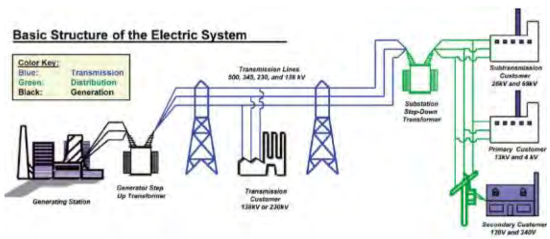
Condition 1: With all relays installed and calibrated.

4. Shaft of a vertical turbine tube-well breaks during operation.

Explanation:

5. During operation of Pump and Motor two phases are interchanged from distribution end (DISCO)

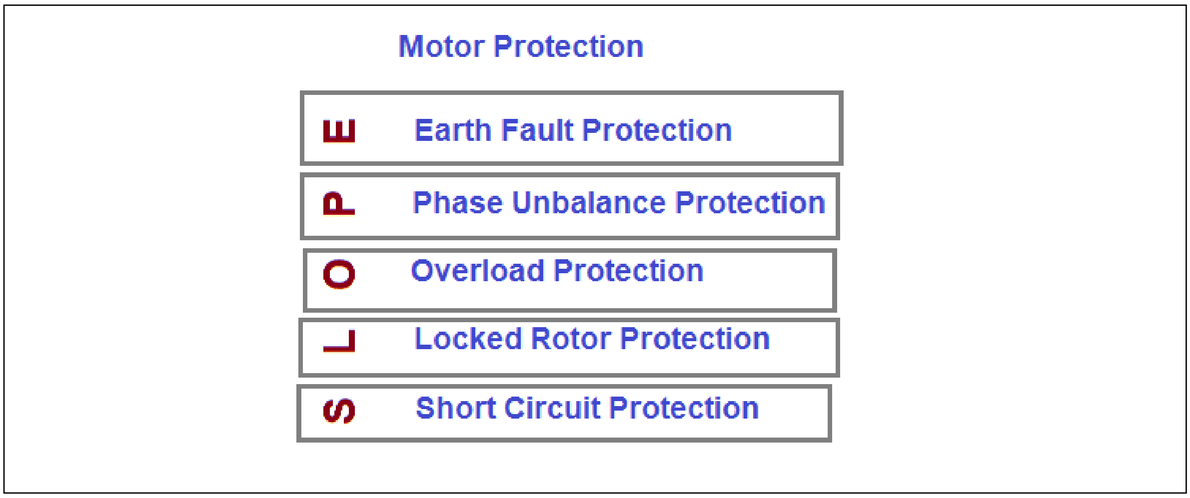
Condition 1: With use of protective relays.



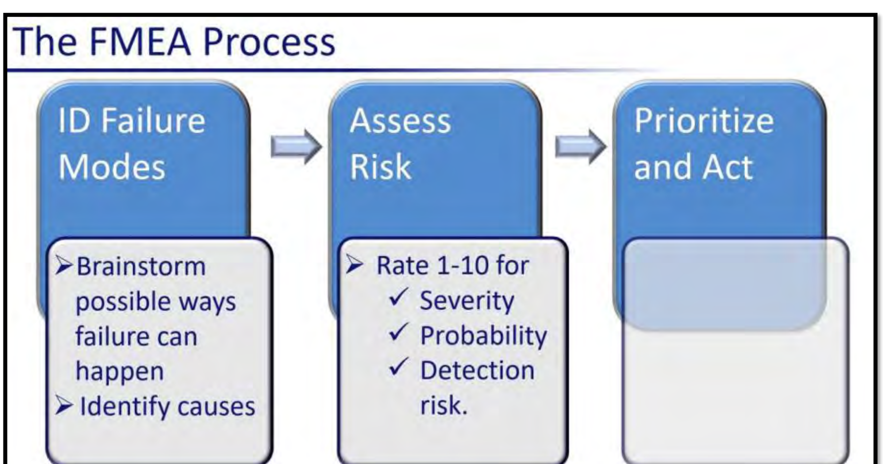
5. During operation of Pump and Motor two phases are interchanged from distribution end (DISCO)

Condition 2: With all protective relays by-passed.

Basics of Motor Protection



Failure Mode and Effects Analysis (FEMA)



Failure Mode and Effects Analysis (FEMA)

	CONSEQUENCES					PROBABILITY				
						1	2	3	4	5
Severity	Classification	Safety	Equipment/ Maintenance Cost	Production	Environmental	< 1% Remote	1% - 5% Extremely Unlikely	5% - 25% Very Unlikely	25% - 50% Unlikely	> 50% Likely
5	Disastrous	Multiple fatalities, > 5. Large effects on large external inhabited zones- several fatalities	Extensive damage >$8M	Major loss, not recoverable. More than 3 days lost production	Major pollution with sustained environmental consequences external to the site	5	10	15	20	25
4	Catastrophic	Lethal effect on several persons (several fatalities). Lethal external effect - one fatality, several physical injuries	Major damage $6M-$8M	Major loss. Up to 50% not recoverable Up to 3 days lost production.	Major pollution external to the site. Evacuation of persons	4	8	12	16	20
3	Major	Lethal effect on one person and/or several permanent invalidities. Permanent external effects	Localized damage $2M - $6M	Medium loss, not wholly recoverable through normal production < 24 hours lost production	Moderate pollution, within site limits. Product liability	3	6	9	12	15
2	Serious	Permanent injury, lost time accident. Non-permanent external effects	Minor damage $200K - $2M	Minor loss, recoverable through normal production 2 to 8 hours lost production	Spill or release of pollutant requiring a declaration to authorities but without environmental consequences	2	4	6	8	10
1	Moderate	No permanent injury, recordable with no lost time/medical treatment. No external effect	Slight damage < $200K	Little to no effect. Production easily recovered. < 2 hour lost production.	Minor spill or release of pollutant, not requiring a declaration	1	2	3	4	5

Risk Assessment Matrix

Risk Matrix

A	B	C	D	E	F
Initial Occurrence	Initial Severity				
	1 - Insignificant	2 - Minor	3 - Significant	4 - Serious	5 - Major
5 - High			1	2	
4 - Moderate			3	5	
3 - Low			1	2	
2 - Very Low					
1 - Remote					

Risk Assessment Matrix (Example)

Initial Occurrence	Initial Severity				
	1 Insignificant	2 Minor	3 Significant	4 Serious	5 Major
5 High					
4 Moderate			Chlorine dosing pump failure		Burnout of MCCB for MCU
3 Low					
2 Very Low		Power Factor Capacitor Failure	Chlorine dosing pump failure		
1 Remote					

Operations and Maintenance Plan

The Urban Unit

ALJAZARI ACADEMY

PRMP

Operations and Maintenance Plan

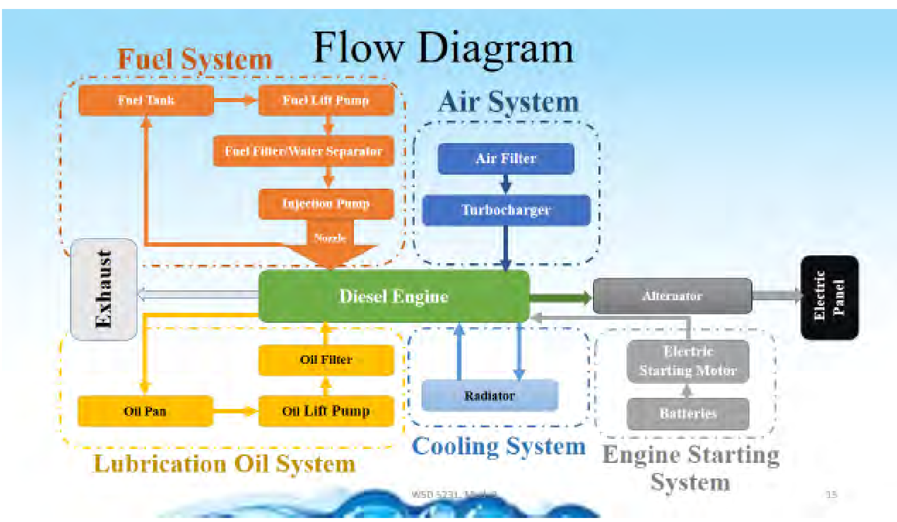
- Operations and Maintenance are the decisions and actions regarding the control and upkeep of property and equipment

  i. Actions focused on scheduling, procedures, and work/systems control and optimization

  ii. Performance of routine, preventive, predictive, scheduled and unscheduled actions aimed at preventing equipment failure

Maintenance Spectrum

Step-I Process Description and Process Flow Diagram



Step-II Equipment Description

- In Case of Tube well

Step-III Operating Procedure

- Submersible Pump Startup & Operation
  - Check water level in bore hole.
  - Check valves (open).
  - Check voltage range for 3-Phase motor.
  - Start up the 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.

Step-III Operating Procedure

- Maintaining procedure log

S.No.	Procedure Description	Procedure No.
1.	Operation of Tubewell	WASA/LAH/44
2.	Gland Packing Replacement	KSB/WASA/LAH/77
3.	MCU Thermal and Insulation Test	PEMPAK/WASA/LHR/22
4.	Energy Audit For Tubewell 4 cfs, JICA	WASA/ELEC/LAH/11

Step-IV Preventative Maintenance Program

S.No.	Equipment	Maintenance	Frequency
1.	Fan Belt of Generator	Visual Inspection	Monthly
2.	Pump Motor Temperature Check	Motor Thermal Check	Quarterly
3.			

Step-IV Evaluation of Facility

- Evaluation of Pumping Facility, Tubewell

S.No.	Procedure Description	Procedure Title
1.	**Evaluation of Motor**	Insulation Test for winding
		Thermal Test for overheating
		RPM Test
		Vibration Test
2.	**Evaluation of Pump**	Flow / Head
		Leakage
		Unusual noise/ vibration

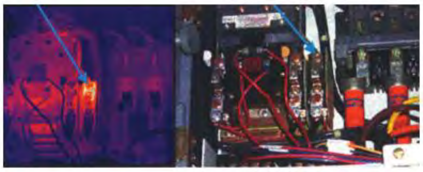
Step-IV Evaluation of Facility

- Evaluation of Pumping Facility, Tubewell

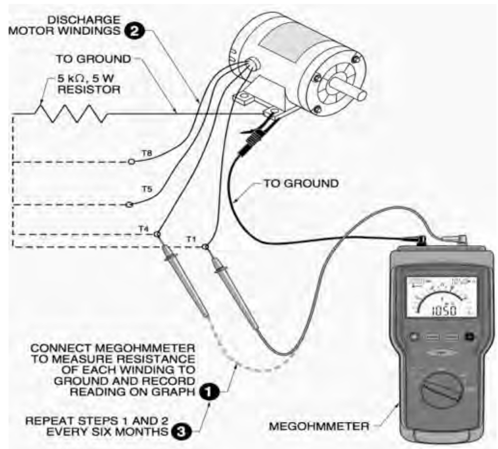
S.No.	Procedure Description	Procedure Title
3.	**Evaluation of Motor Control Unit**	Insulation Test for Wiring and components
		Earth Resistance Test
		Thermal Test for overheating
		Lamp test for warning signs
4.	**Evaluation of Valves**	Check operation of Air Release Valve
		Check operation of Non return Valve
		Check Operation of Gate Valve
5.	**Tubewell Chamber Evaluation**	Visual Inspection

Step-IV Evaluation of Facility

- Evaluation of Pumping Facility, Tubewell

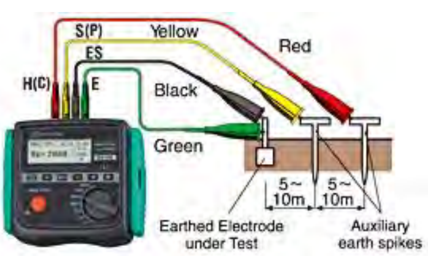


Overloaded contacts show different temperature profiles indicating
one contact seeing much greater load, a potentially unsafe situation.



Step-IV Evaluation of Facility

- Evaluation of Pumping Facility, Tubewell



Earth Resistance Test

Vibro-meter

Contact and Non Contact type Tachometer

Step-IV Evaluation of Facility

- Evaluation of Pumping Facility, Tubewell

Ultrasonic Flow meter

Step-IV Report Writing

- Annual Maintenance Plan

Daily and Periodic Maintenance Sheet

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

Annual Maintenance plan

- Step-I Process Description and Process Flow Diagram
- Step-II Equipment Description
- Step-III Operating Procedure
- Step-IV Preventative Maintenance Program (Evaluation of Facility)
- Maintenance plan

Contact:

Engr. Jawad Shahid

WASA field Issues

Suggested Improvement

Suggested Improvement


Suggested Improvements


Suggested Improvements



Suggested Improvements


Current Conditions

Suggested Improvement

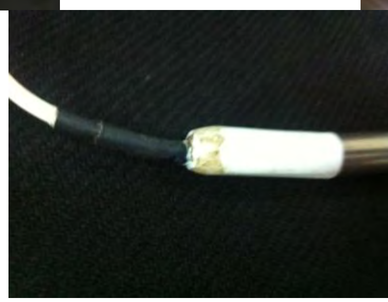
Suggested Improvement

WASA FIELD ISSUES

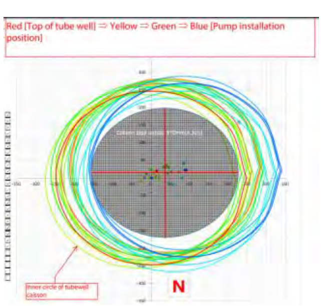
Water Level Indicator Usage Issue

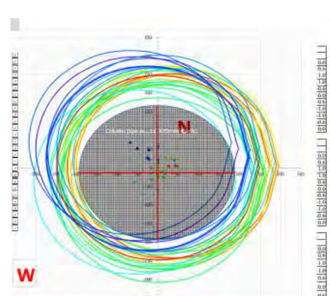
Water Level Indicator Usage Issue

Water Level Indicator Usage Issue



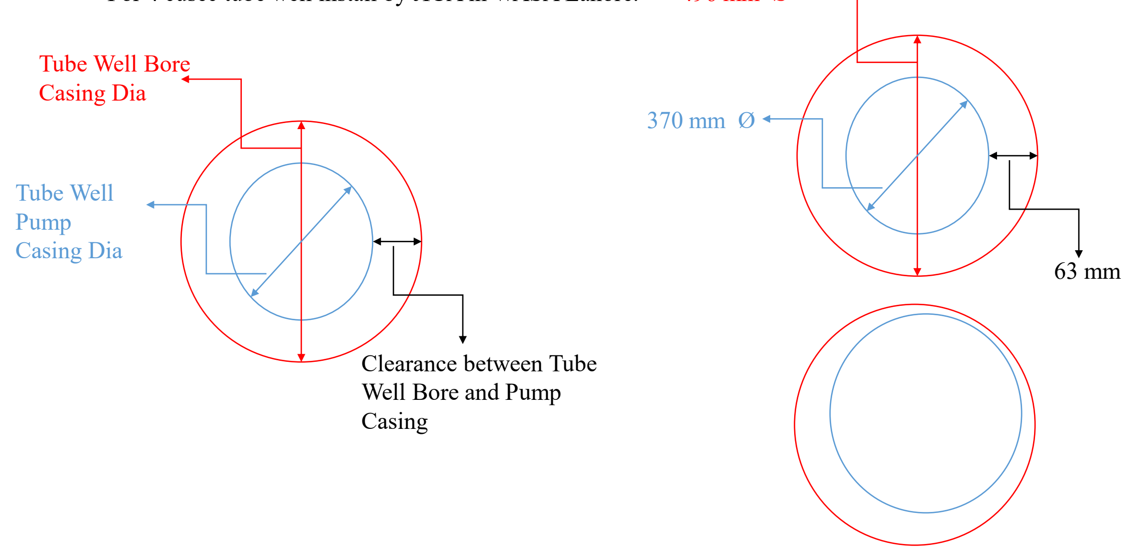
Water Level Indicator Usage Issue





Water Level Indicator Usage Issue

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



Water Level Indicator Usage Issue

Valves maintenance issue in WASAs

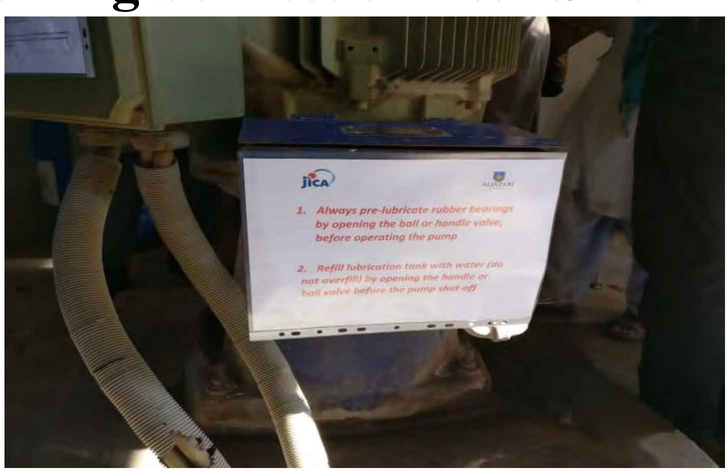
- Cracked gasket

Valves maintenance issue in WASAs

- Absence of balls in air release valves

Lubricating box issue in WASAs

Lubricating box issue in WASAs



Thank you

Engr. Jawad Shahid

Annex 5.1.52 Training Material for "Leakage Control, Plumbing and Pipe Replacement Plan" in Spring 2023

In the name of Allah, the most Gracious and ever Merciful

Welcome To All Stakeholders

Course Team

Ms. Rebia Suhail	Course Lead
Mr. Syed Fahad Hussain	Module Lead
Mr. Wajih	JICA Coordinator
Mr. K Kayanoma	JICA Expert

WATER METER

1 Purpose
2 Knowledge acquisition
2.1 Meter reading
2.2 Type of meter
3 Metrology, Meter classes and other requirements
3.1 Definition of meter accuracy
3.2 Meter error curve
4 Meter maintenance

PURPOSE

Purpose of training

Understand meter reading, Type of meters, meter accuracy & class, maintenance.

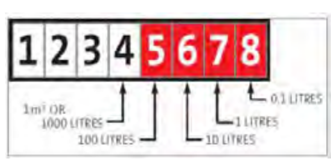
METER READING

The water meter shows several digits as shown in the figure. This digit means 1234 m3 and 567.8 liter, or 1234.5678 m3. When the counter of 0.1 liters is moving between two numbers, it is counted as lower number.

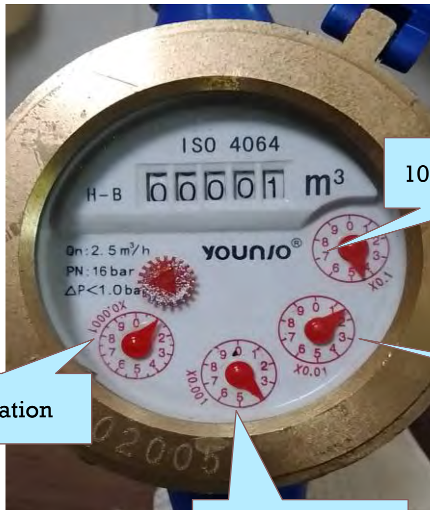
m3 is shown in the upper black digits and liter is shown in the lower red pointer. When the pointer is between two numbers, it is counted as lower number.

When the digit of counter reached maximum (e.g. 9999.999), it back to all zero (e.g. 0000.000), and sometimes it makes mistakes of calculation of consumption. As shown below, it is necessary to calculate on the assumption that it has one digit in the left side which is not shown on the display.

JIS : Japanese Industrial Standards（JIS B 8570-1:2013）

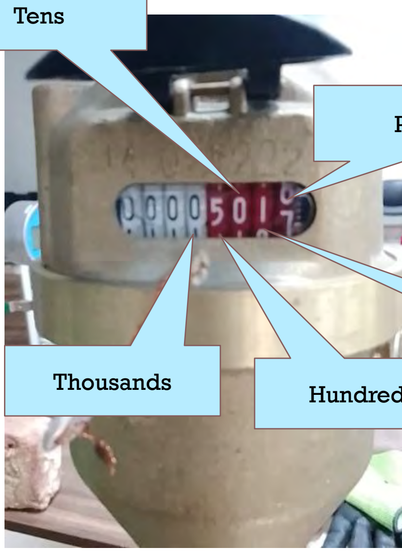


DISPLAY OF WATER METER



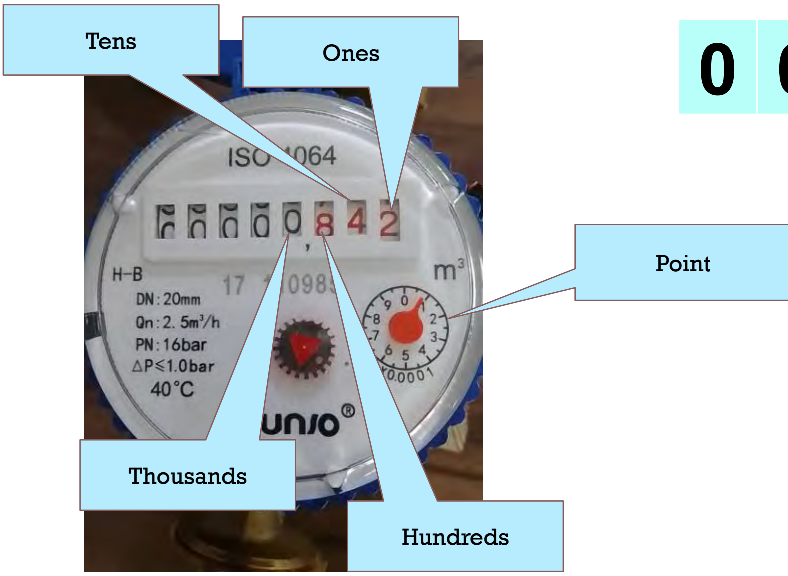
0 0 1 4 1 4.1

DISPLAY OF WATER METER



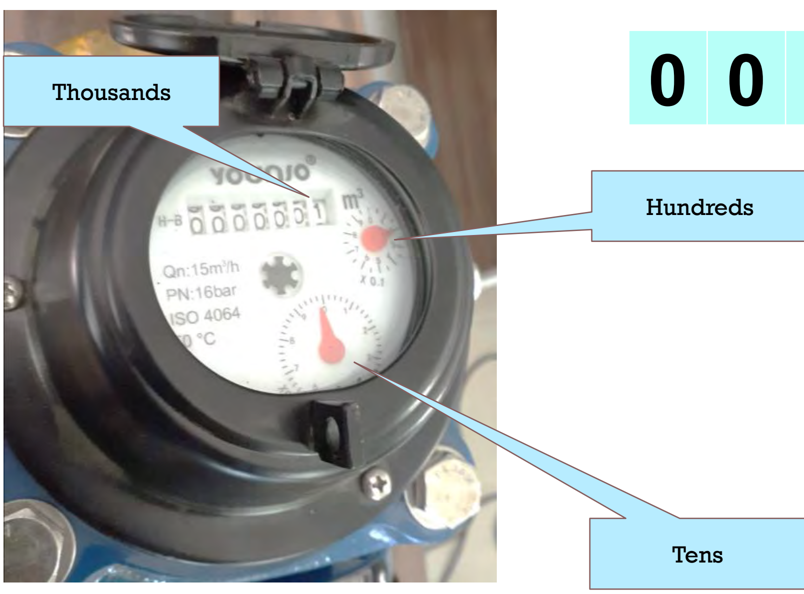
0 0 0 5 0 1.7

DISPLAY OF WATER METER



0	0	0	8	4	2.	1

DISPLAY OF BULK METER



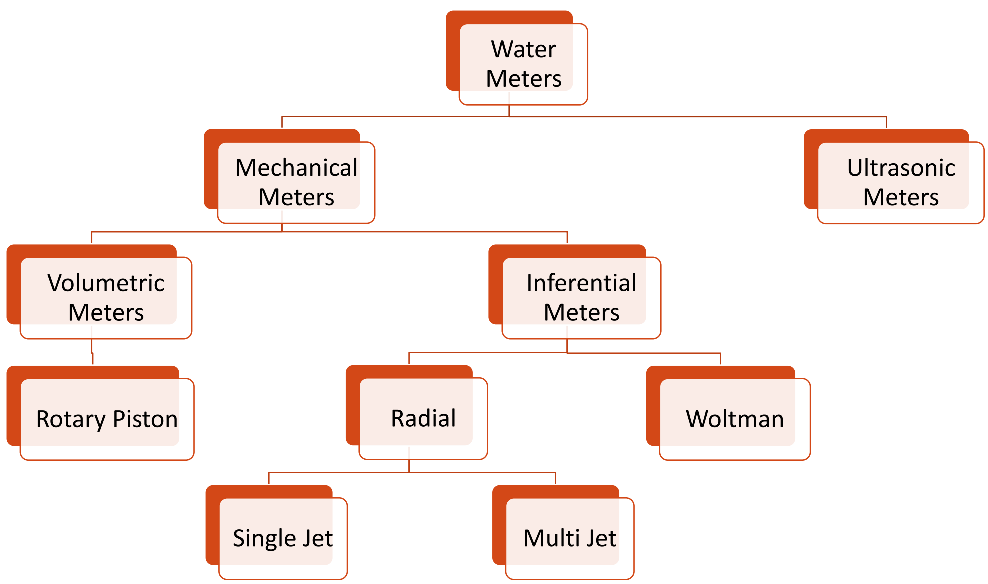
0	0	0	1	1	9	8

METER READING

	1	2	Difference (2-1)	3	4	Difference (4-3)
Bulk Meter						
R M 1						
R M 2						
R M 3						
R M 4						
Total RM						
L M 1						
L M 2						
L M 3						
L M 4						
Total LM						

TYPE OF METER

THE TYPE OF WATER METER IS CLASSIFIED AS BELOW.



WOLTMAN METERS

<Mechanism>

The Woltman meters are an inferential meter that uses an impeller with helical vanes. As water flows over the helical vanes, it rotates the impeller. Then, the rotation is transmitted to the dial via reduction gearing.

There are two main types of Woltmann meters called Horizontal (WP) and Vertical (WS) Woltmann meters. Horizontal Woltmann meters have their inlets and outlets directly along the pipeline. The axle of the helical vane is parallel to the flow.

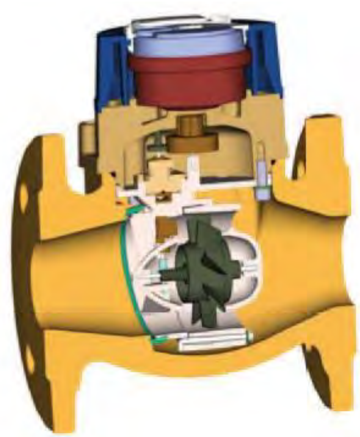
Water flows directly through the meter with small loss caused by the meter body.

The flow direction is changed 90 degrees after entering a vertical Woltmann meter, pass through the impeller and then turn back to the original direction as shown in the cross section of left Figure.

Woltmann meters have dry and sealed dials.

➢ Advantages: No power required, Highly accurate

➢ Disadvantages: If a foreign substance gets in, accuracy falls, or the impeller will be damaged. Piping friction loss occurs. Not applicable to large diameter pipes.



APPLICATION AND INSTALLATION

Woltmann meters are widely used throughout the world. They are mainly used to measure the consumption volume of bulk users, or to determine the flow pattern in water distribution systems. Horizontal Woltmann meters can be installed in all directions without affecting the accuracy. The counter, however, should never be placed upside down. Vertical Woltmann meters must be installed horizontally with the display facing upwards.

➢ Applicable pipe diameter: 40mm – 400mm

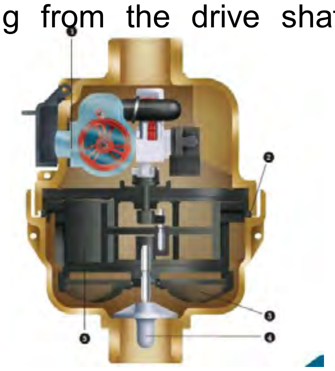
➢ Suitable installation location: Place where the power is out and there is no cover to protect rainwater

ROTARY PISTON METERS

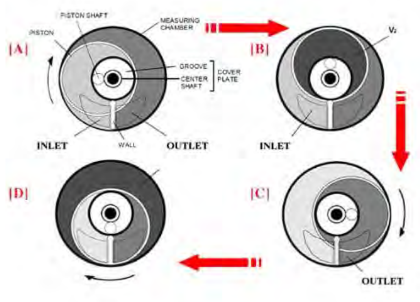
Rotary piston meters are popular for their combination of accuracy, long life and moderate cost so they are widely used. Rotary piston meters come in many different shapes and sizes as shown. Wet or dry dials are used. Sand or other suspended solids easily get stuck between the piston and chamber wall. Thus, it is important to be installed in the system with very good water quality and to install built-in strainer.

<MECHANISM>

The piston and cylinder are alternately filled and emptied by the fluid passing through the meter. A slot in the sidewall of the piston is removed so that a partition extending inward from the bore of the working chamber can be inserted. This has the effect of restricting the movement of the piston to a sliding motion along the partition. The rotary movement of the piston is transmitted via a permanent-magnet coupling from the drive shaft to a mechanical register.



1. Easy to read register
2. ”O” ring seal
3. Stainer
4. Non-Return valve
5. Piston and cylinder



Application and Installation

Rotary piston meters are commonly used most domestic applications up to diameter 25mm. They are not sensitive to the wide flow velocity profile.

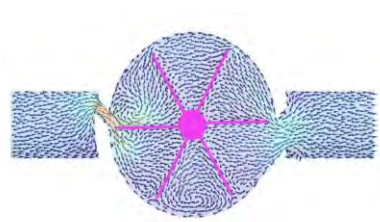
Rotary piston meters can be installed in **any position** with stable accuracy and placed close to bend or pump.

➢ Applicable pipe diameter: 13mm – 40mm

➢ Suitable installation location: Place where the power is out and there is no cover to protect rainwater

SINGLE JET METERS

- Single-jet meters are a low-cost option because there's a direct impact to the impeller by the water flow
- The water is channeled through a single jet over a impeller placed inside the body of the meter. Impeller circulating the flowrate.
- Resistant to suspended solids.
- Small and can be installed in tight spaces.
- Most single jet meters have to be installed perfectly horizontally and upright to ensure accurate measurements



MULTIPLE JET METERS

<Mechanism>

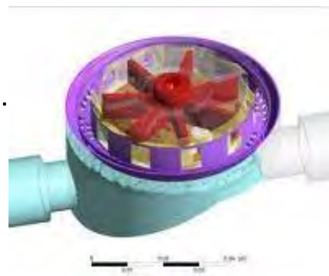
The multi jet meters are an inferential water meter. Their operation is similar to that of single jet meter, except that they use several jets to drive the impeller at multiple points.

This means that the forces on the impeller are better balanced than in single jet meters, which reduces wear on the moving parts and provides greater durability. A cutaway view of a multi jet meter is shown in the left photo.

Multi jet meters normally use an internal bypass with a regulating screw to adjust the flow passing through the impeller. This allows the manufacturer to adjust the meter's error curve for achieving the best accuracy before sealing it for the prevention of meter tampering. A strainer is installed on the inlet side, which can be removed for cleaning.

➢ Advantages: No power required, Accurate at low flow rate

➢ Disadvantages: If a foreign substance gets in, accuracy falls, or the impeller will be damaged. Piping friction loss occurs. Not applicable to large diameter pipes.

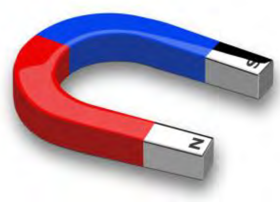


COMPARISON OF WATER METERS

	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

METER TAMPERING

Unauthorized manipulation of the water meter for the purpose of stealing water. The offense also includes placing magnets, placing foreign objects inside the meter inverting the position of the meter, breaking water meters: all for the purpose of slowing down the meter registry eventually lessen water consumption



3 METROLOGY, METER CLASSES AND OTHER REQUIREMENTS

3.1 DEFINITION OF METER ACCURACY

The volume of water that passes through a water meter is called the actual volume, or Va. However, since no meter is 100% accurate, the meter will not register all the water passing through it but show a indicated volume (Vi), which is slightly lower or higher than the actual volume. The difference between the indicated volume and actual volume (Vi - Va) is called the meter error. When the error is expressed as a fraction (percentage) of the actual volume, it is called as the relative error.

[Relative error]: (Vi - Va) / Va x 100 (%)

Where: Vi is the indicated volume. Va is the actual volume.

3.1 DEFINITION OF METER ACCURACY

- **CALCULATION OF THE ERROR (%)**

$$\text{Error (\%)} = \frac{\text{Indicated Volume (meter reading result)} - \text{Actual Volume}}{\text{Actual Water Volume}} \times 100$$

METER ERROR CURVE

➢ Q1 – Minimum flow rate:

The lowest flow rate at which the meter is required to give indications within the maximum permissible error tolerance (± 5% error).

➢ Q2– Transitional flow rate:

The flow rate at which the maximum permissible error of the water changes in value from ± 5% error to ± 2% error.

➢ Q3 – Permanent flow rate:

Permissible continuous load. Half the maximum flow rate (± 2% error).

➢ Q4 – Maximum flow rate (Overload Flow Rate):

The highest flow rate at which the meter is required to operate in a satisfactory manner for a short period without deteriorating (± 2% error)

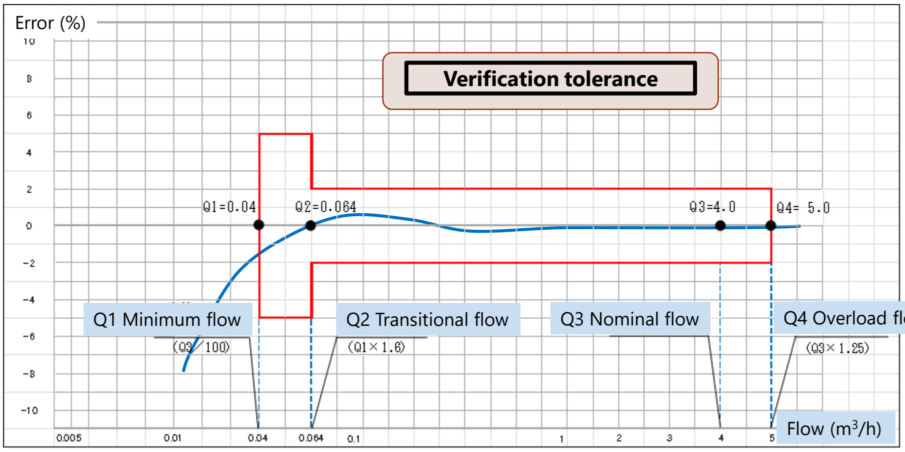
METER ERROR CURVE

Water meters are designed for a specific flow rate, which is called as the permanent flow rate or Q3.The meter should be able to work at the permanent flow rate (or a lower flow rate) continuously for its design life without exceeding the permissible error.

Although a meter is designed for the permanent flow rate, the actual flow through a meter is not constant. Thus, water meters should not only be accurate at the permanent flow rate, but also be accurate over a wide range of flow rates.

It is useful to draw a graph of a meter's relative error. This curve is called the meter's error curve.

3.2 METER ERROR CURVE



MAINTENANCE

The proper maintenance of any metering device is essential to ensure the accuracy. Most meter manufacturers have a recommended maintenance and testing method in the operation manual.

The most common problems experienced with water meters in the field are as below:

➢ Suspended solids in the water cause stuck or damage of meter and meter strainer. These solids enter the system most often due to:

- Large pipe bursts.
- Inadequate flushing of pipes after installations or repairs.
- High velocities in the network stir up sediments that was accumulated on the bottom of pipes.
- Inadequate water treatment or malfunction of treatment plants.

A strainer should be installed upstream of the meter to protect the rotor from objects such as stones and pebbles. As for maintenance, the strainer needs to be cleaned regularly.

SERVICE PIPE

SERVICE PIPE

1 Purpose of training

2 Knowledge acquisition

2.1 Outline of PPR pipe

3 Jointing method

3.1 Socket fusion joint

3.2 Thread joint

4 Practice

1 PURPOSE OF TRAINING

The purpose of this training is to provide a practical training on installation of PPR service pipes. Also, it is important to share the knowledge of this training with not only the staff of WASA but also contractors.

2 KNOWLEDGE ACQUISITION

2.1 Outline of PPR

➢ Standard of PPR pipes

 ISO 15874 standard green PPR pipe, DIN 8077-8078 hot water PPR pipe.

PPR pipes & fittings Characteristics:

1. Well heart resistance ability
   The pipes can be used for a long time while the working temperature of water is 70℃
2. Well insulation ability
3. Long lifetime span
   Under normal conditions of temperature and pressure PPR pipe can be over 50 years.
4. Little resistance for water flow
   The inner walls of PPR pipes are smooth and limescale will not be formed there
5. Economical
6. Light weight
7. Well corrosion resistance

3 JOINTING METHOD

There are mainly two jointing method for PPR distribution pipes: Socket fusion joint and Thread joint.

3.1 Socket fusion joint

Socket fusion joint Details

Socket fusion joint connect PPR pipe and socket by heat of socket fusion welding machine. This method is very common way to joint PPR service pipe and the durability of this joint part is high.

3.2 Thread joint

Thread joint Details

Male thread and female thread are used for thread joint. The thread has shape of screw and male thread and female thread can be connected very easily and swiftly.

4 PRACTICE

【Preparation Item】

- Socket fusion welding machine
- Scale
- Elbow
- PPR pipe
- Pipe cutter

STEPS PROCEDURES

1. Check the pipe and socket whether they are damaged or not.
2. Measure the depth of socket and mark the insertion length on the pipe surface.
3. Cut the pipe at right angles by using a pipe cutter.
4. Always ensure that the welding machine corresponds to the required jointing size.
5. Required operating temperature of the welding machine is 250℃-270℃
6. Push the end of the pipe and socket into socket fusion welding machine up to the marked insertion length. Be careful not to turn the pipe and socket while heating.
7. Pull out the pipe and socket from the socket fusion welding machine after proper heating time, insert the pipe into socket evenly and swiftly and wait until they cool down.

STEPS PROCEDURES

Outside Diameter	Average Heating Time*	Average Working Time (max.)	Average Cooling Time (min.)
mm	sec	sec	min
20	5	4	2
25	7	4	2
32	8	6	4
40	12	6	4
50	18	6	4
63	24	8	6
75	30	8	6
90	40	8	6
110	50	10	8

Ultrasonic Flow Water Meter

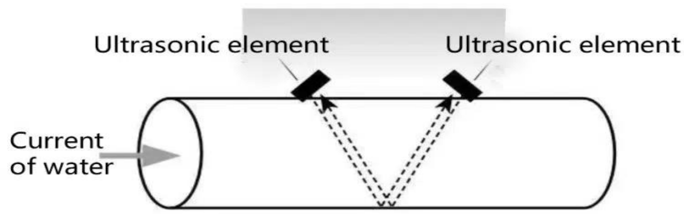
Mujtaba Bashir
Project Officer
(E&M)Equipment

What is ultrasonic flow meter?

Ultrasonic flow meter is an instrument that measures flow by detecting the action of a fluid flow on an ultrasonic beam (or ultrasonic pulse).

Ultrasonic flow meter working principle

- upstream and downstream sensors
- Sends and receives ultrasonic waves in both directions.
- Under no-flow conditions, the flow time is the same between the flow sensor upstream and downstream.
- As the liquid flows faster, the difference between the upstream and downstream times will increase



Structure diagram of ultrasonic flowmeter

Features of Ultrasonic Flow Meter

Advantages

- It does not block the path of liquid flow.
- The meter has a good dynamic response.
- Energy conservation
- Suitable for large mass flow measurements
- Easy to install and maintain
- Very good versatility
- No risk of leakage
- No moving parts, pressure loss

Disadvantages

- It is expensive compared to other mechanical flow meters.
- The meter’s design is complex
- The audible parts of this meter are expensive.
- These meters are complex compared to other meters and therefore require professionals to maintain and repair these meters
- It cannot measure rusty cement or concrete pipes.
- It does not work once there are holes or air bubbles in the pipe
- It cannot measure cement/concrete pipes or pipes lined with this material

Ultrasonic Flow Meter Installation Guidelines

- The straight pipe should be long enough to eliminate the irregular-flow-induced error.
- Make sure that the pipe is completely full of liquid.
- Make sure that the temperature on the location does not exceed the range for the transducers.
- Tightly fix the probes on the pipe.

Ultrasonic Thickness Gauge

It is used to measure the wall thickness of materials such as steel, plastic, and more.

EPANET Software

HYDRAULIC MODELING

Application for Modeling Drinking Water Distribution Systems

Instructor

Muhammad Uzair Safdar

Topics covered in Presentation

- Introduction to EPANET
- Pipe network elements
- Steps in using EPANET
- Simple network analysis example

Introduction To EPANET

- A network analysis computer program developed by the U.S. Environmental Protection Agency that analyzes Water Distribution Network
- A tool to determine pressure, velocity and flow in different pipes in a Network
- EPANET to design and size new water infrastructure, retrofit existing aging infrastructure, optimize operations of tanks and pumps, reduce energy usage, investigate water quality problems, and prepare for emergencies. It can also be used to model contamination threats and evaluate resilience to security threats or natural disasters.

What is EPANET

- EPANET performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks.
- Pipe network consists of pipes, nodes (pipe junctions), pumps, valves, storage tanks and reservoirs.
- EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank.
- EPANET use for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include color-coded network maps, data tables, time series graphs, and contour plots.

How to Download

https://www.epa.gov › water-research › epanet

EPANET | US EPA

01-Feb-2022 — EPANET is **a software application used throughout the world to model water distribution systems**. It was developed as a tool for understanding ...

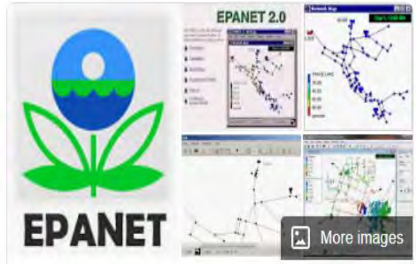
Software, Compatibility, and... · Capabilities · Applications

People also search for

is epanet free	epanet logo
epanet tutorial	epanet uses
epanet examples	epanet pdf

People also ask

What is EPANET software used for?



EPANET

System software

EPANET is a public domain, water distribution system modeling software package developed by the United States Environmental Protection Agency's Water Supply and Water Resources Division. Wikipedia

Download Software

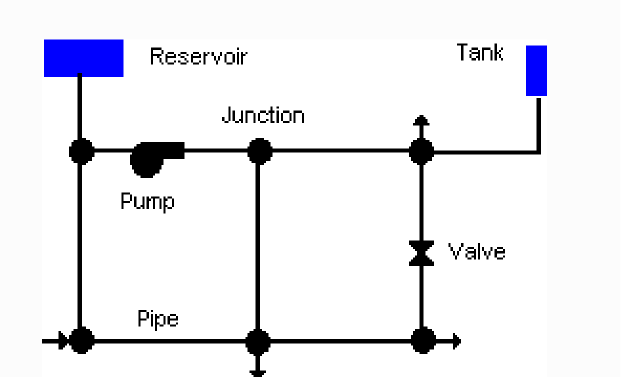
- EPA's GitHub site for EPANET 2.2 open source project

Software

Date	Description
07/23/2020	Self-Extracting Installation Program for EPANET 2.2 (EXE) (3.5 MB)
07/23/2020	Non-Installing Software for EPANET 2.2 (ZIP) (2.84 MB)
10/01/2018	Self-Extracting Installation Program for EPANET 2.00.12 (EXE) (exe)

Pipe Network Elements

EPANET uses various types of objects to model a distribution system. These objects can be accessed either directly on the network map or from the Data page of the Browser window.

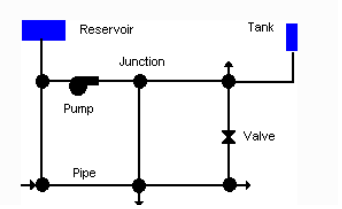


Physical Components in a Water Distribution System

Links

Links that convey water from one point in the network to another.

- Pipes
- Pumps
- Valves



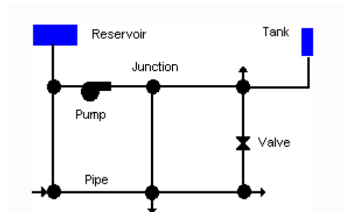
Pipes

The principal hydraulic input parameters for pipes are:

- Start and end nodes
- Diameter
- Length
- Roughness coefficient (for determining headloss)

Nodes

Nodes are points in the network where links join together and where water enters or leaves the network.



- Junctions
- Reservoirs
- Tanks

Junction

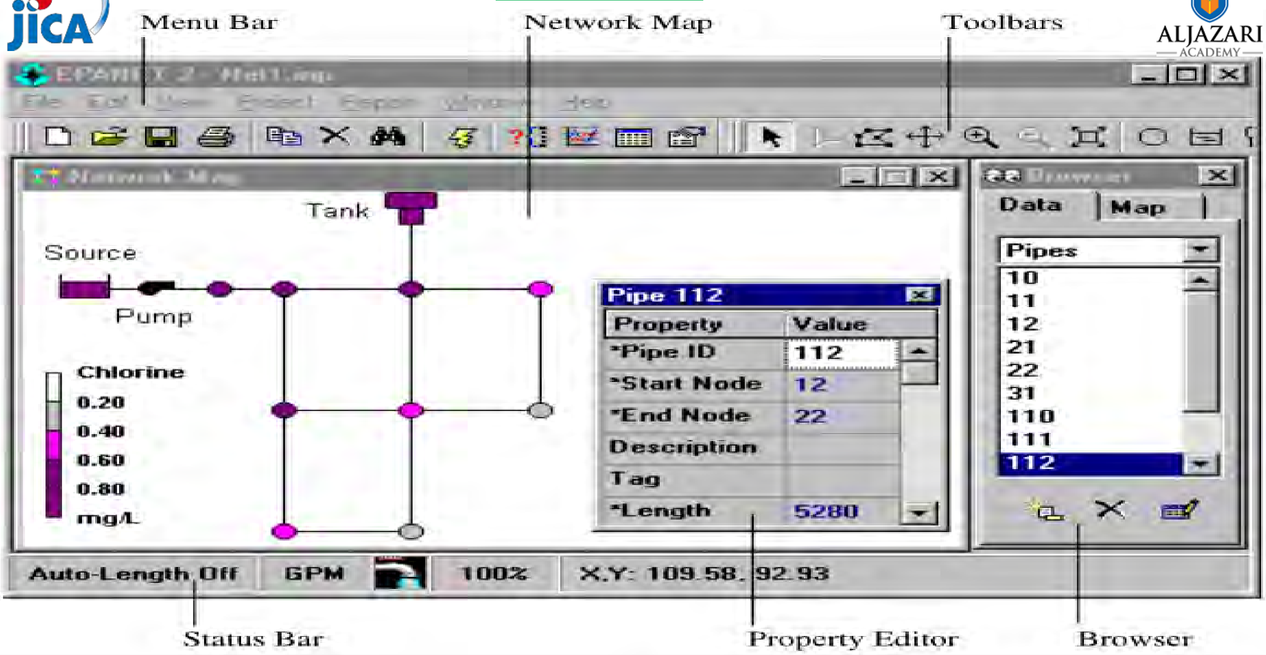
The basic input data required for junctions are

- Elevation above some reference (usually mean sea level)
- Water demand (rate of withdrawal from the network)
- Initial water quality

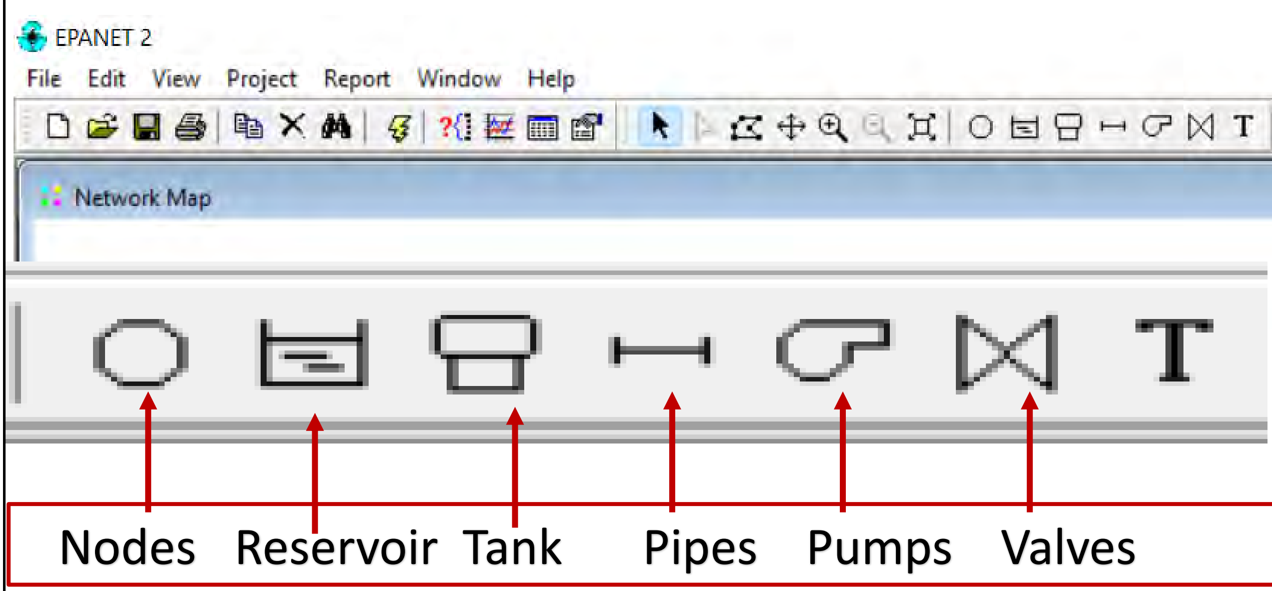
Reservoirs

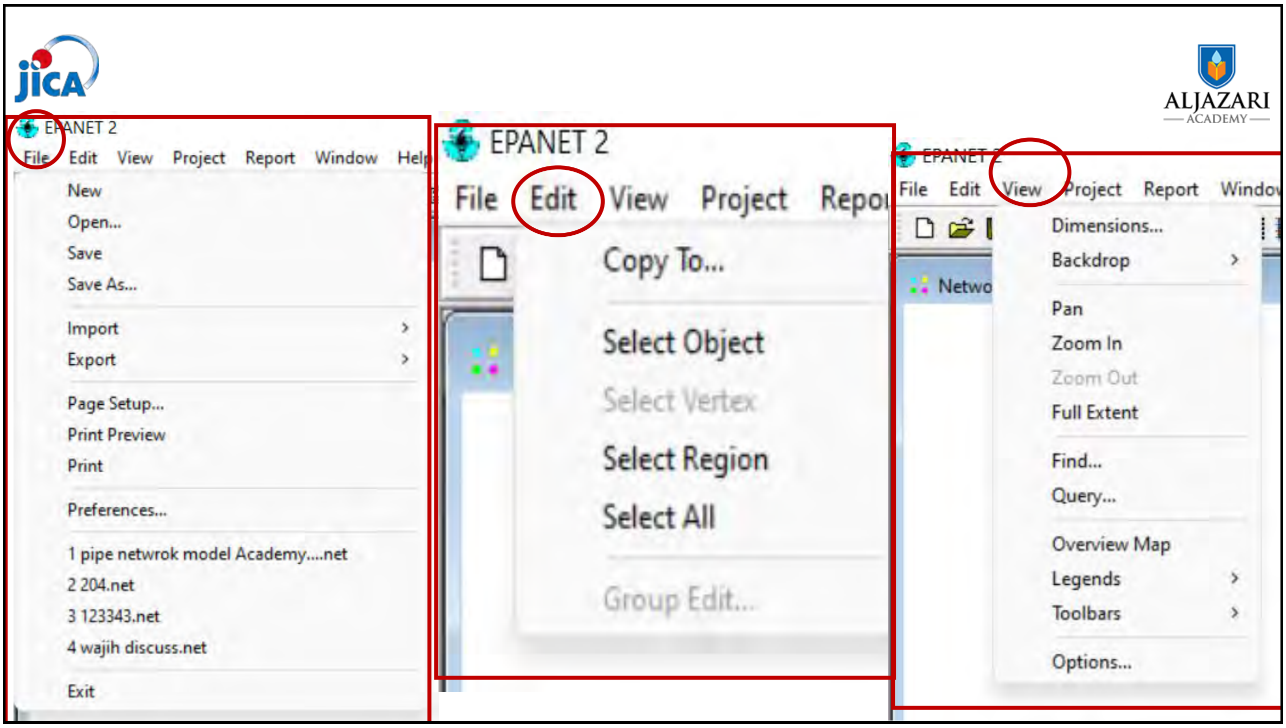
Reservoirs are nodes that represent an infinite external source or sink of water to the network. They are used to model such things as lakes, rivers, groundwater aquifers, and tie-ins to other systems. Reservoirs can also serve as water quality source points.

Interface

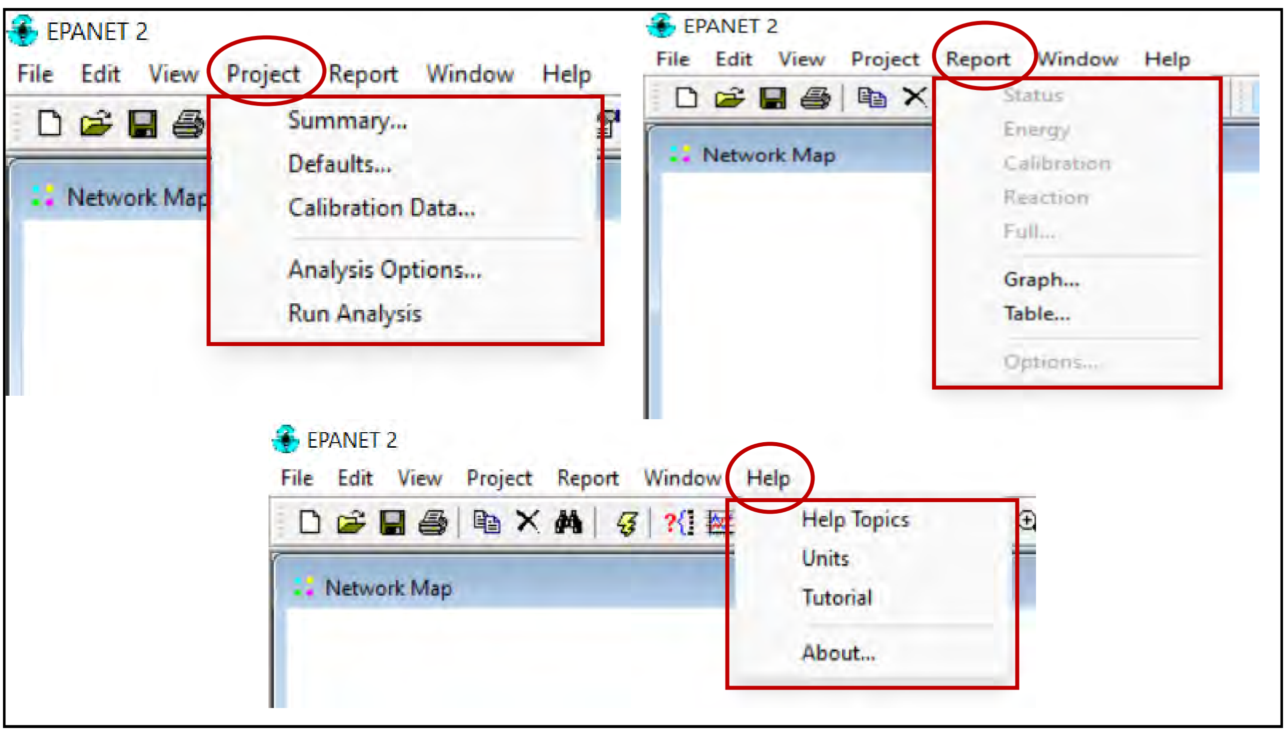


EPANET Software Interface

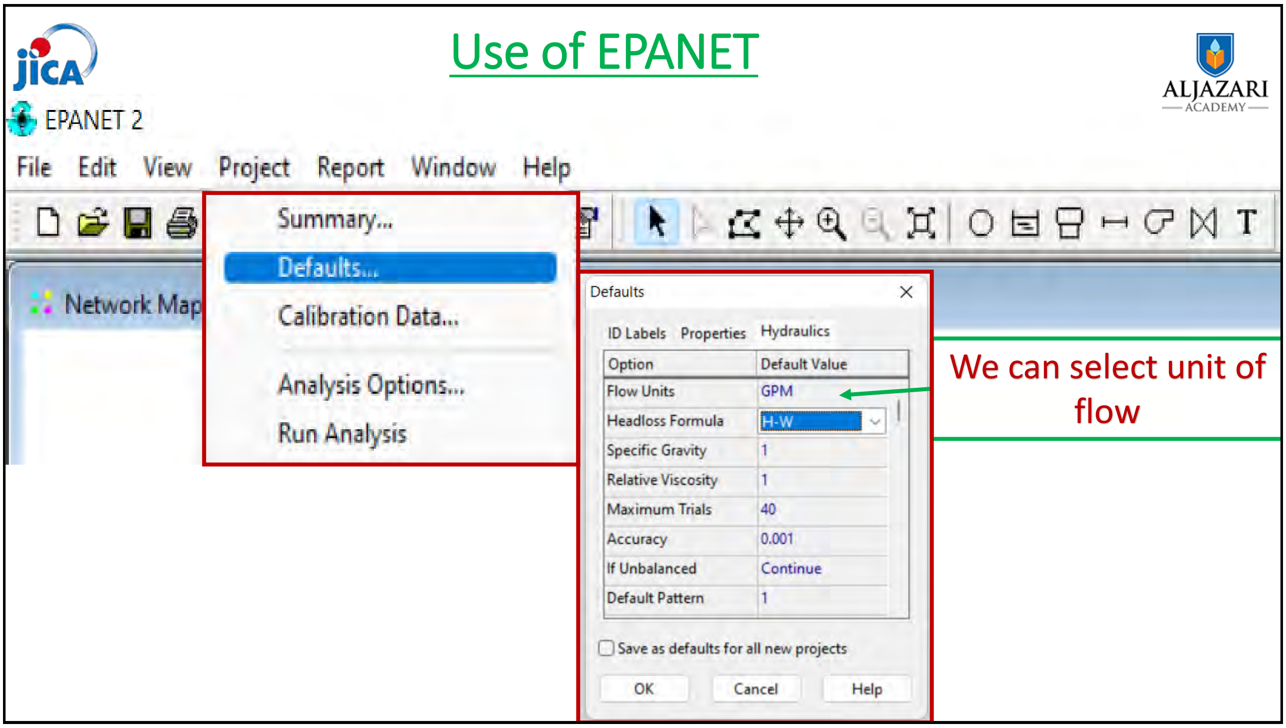


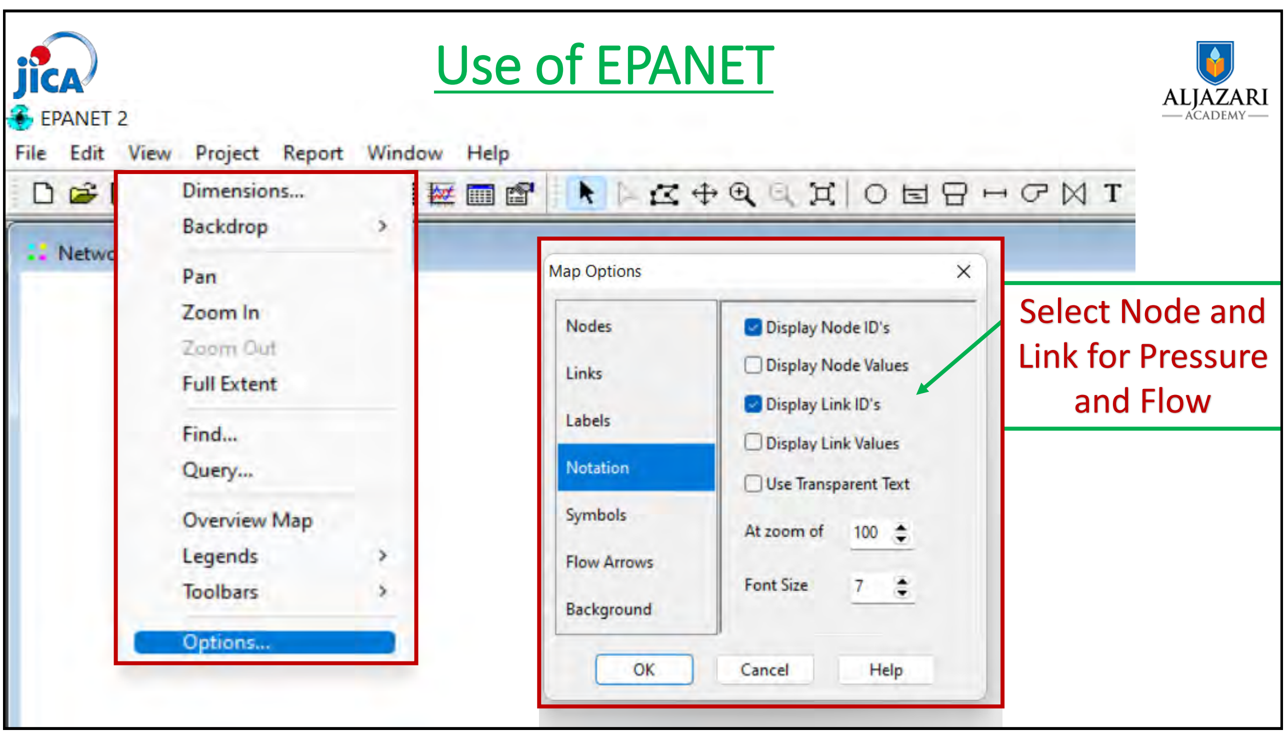


EPANET 2
File Edit View Project Report Window Help
New
Open...
Save
Save As...
Import
Export
Page Setup...
Print Preview
Print
Preferences...
1 pipe netwrok model Academy....net
2 204.net
3 123343.net
4 wajih discuss.net
Exit
EPANET 2
File Edit View Project Repor
Copy To...
Select Object
Select Vertex
Select Region
Select All
Group Edit...
File Edit View Project Report Windo
Netwo
Dimensions...
Backdrop
Pan
Zoom In
Zoom Out
Full Extent
Find...
Query...
Overview Map
Legends
Toolbars
Options...
ALJAZARI
ACADEMY



EPANET 2
File Edit View Project Report Window Help
Network Map
Summary...
Defaults...
Calibration Data...
Analysis Options...
Run Analysis
EPANET 2
File Edit View Project Report Window Help
Network Map
Status
Energy
Calibration
Reaction
Full...
Graph...
Table...
Options...
EPANET 2
File Edit View Project Report Window Help
Network Map
Help Topics
Units
Tutorial
About...


Use of EPANET
ALJAZARI
ACADEMY
EPANET 2
File Edit View Project Report Window Help
Summary...
Defaults...
Calibration Data...
Analysis Options...
Run Analysis
Network Map
Defaults
ID Labels Properties Hydraulics
Option Default Value
Flow Units GPM
Headloss Formula H-W
Specific Gravity 1
Relative Viscosity 1
Maximum Trials 40
Accuracy 0.001
If Unbalanced Continue
Default Pattern 1
Save as defaults for all new projects
OK Cancel Help
We can select unit of flow


Use of EPANET
ALJAZARI
ACADEMY
EPANET 2
File Edit View Project Report Window Help
Dimensions...
Backdrop
Pan
Zoom In
Zoom Out
Full Extent
Find...
Query...
Overview Map
Legends
Toolbars
Options...
Map Options
Nodes
Links
Labels
Notation
Symbols
Flow Arrows
Background
Display Node ID's
Display Node Values
Display Link ID's
Display Link Values
Use Transparent Text
At zoom of 100
Font Size 7
OK Cancel Help
Select Node and Link for Pressure and Flow

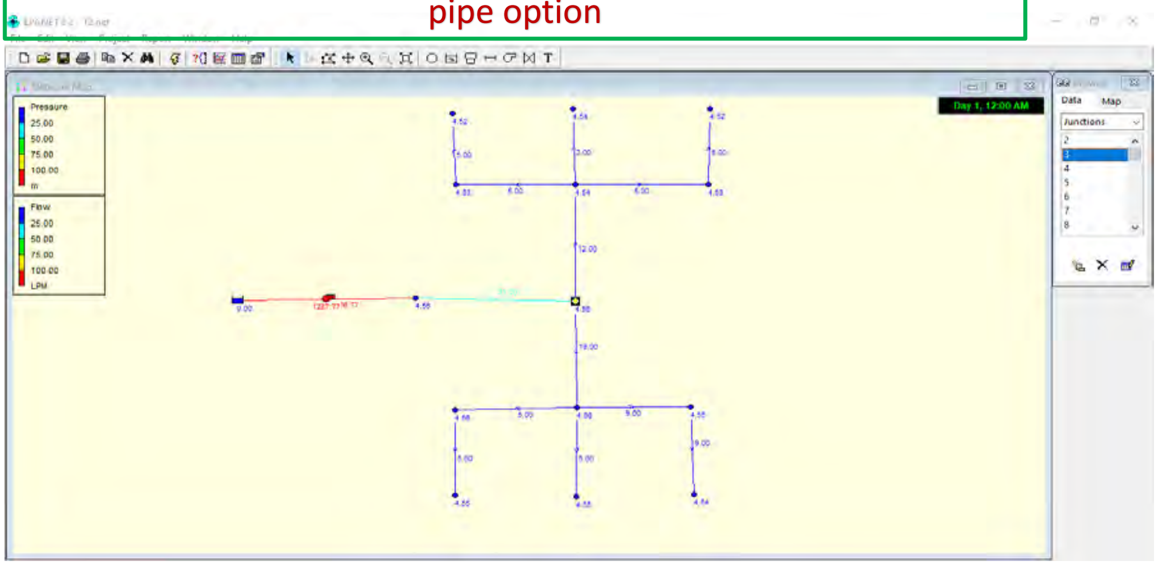
Modeling of Pipe Network

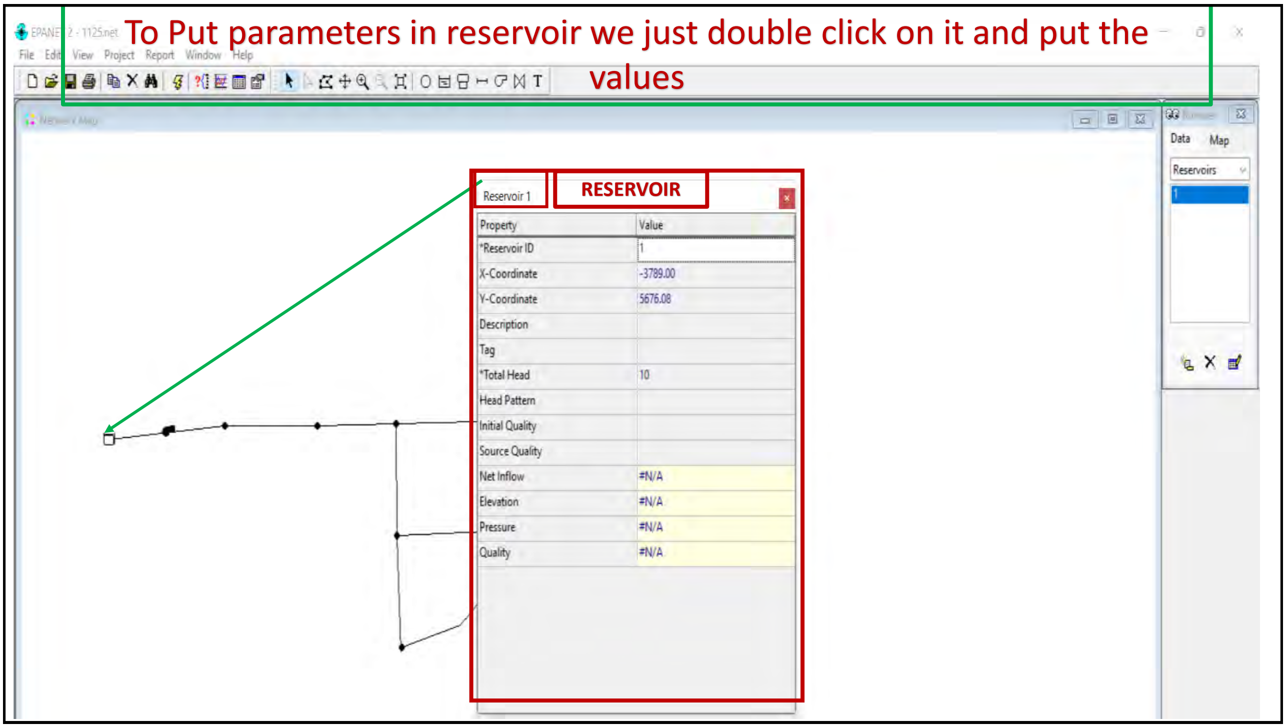
Following steps are carried out when using EPANET to model a water distribution system:

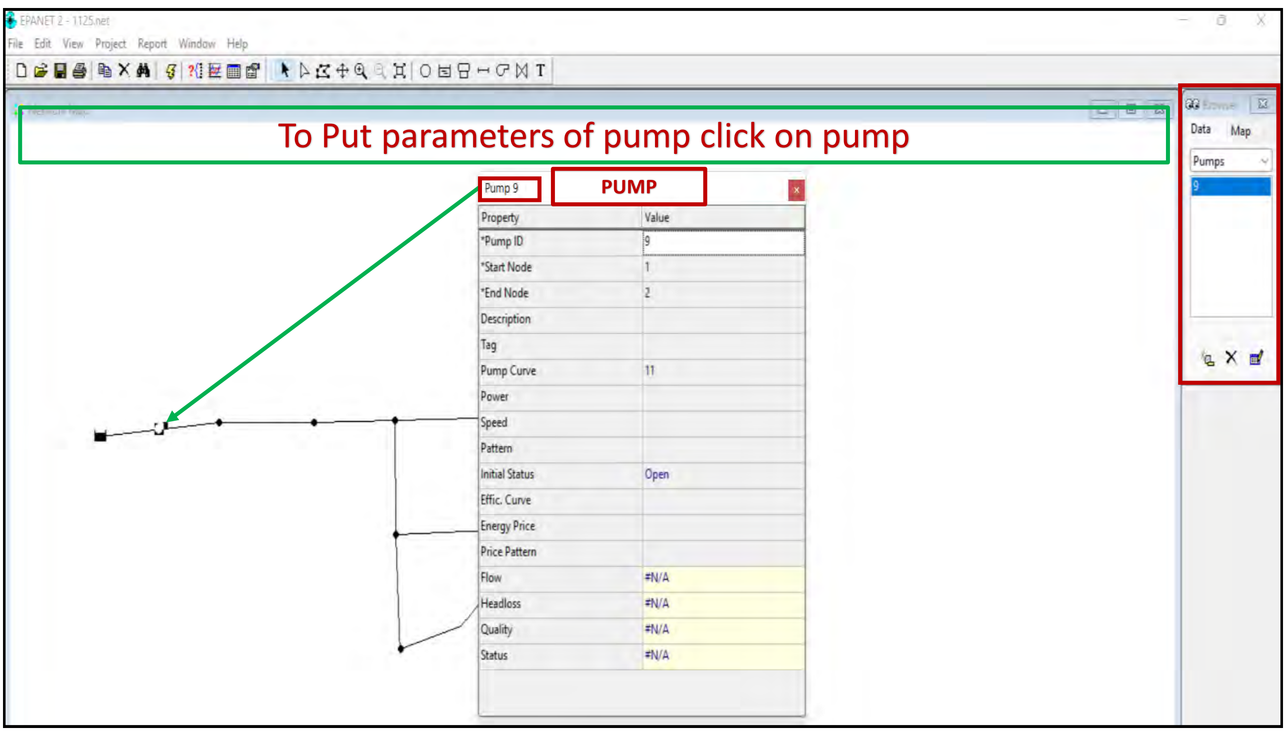
- Draw a network representation of your distribution system
- Edit the properties of the objects that make up the system
- Describe how the system is operated
- Select a set of analysis options
- Run a hydraulic/water quality analysis
- View the results of the analysis

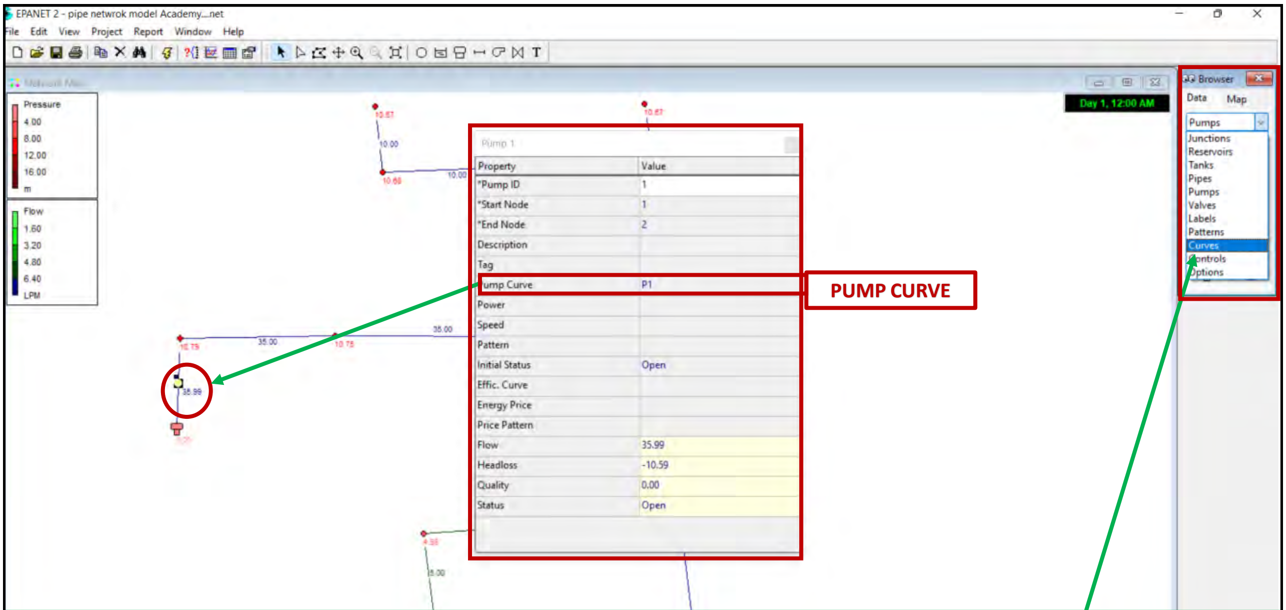
Modeling of Pipe Network

Using Different tools make model and connect the nodes with pipe option

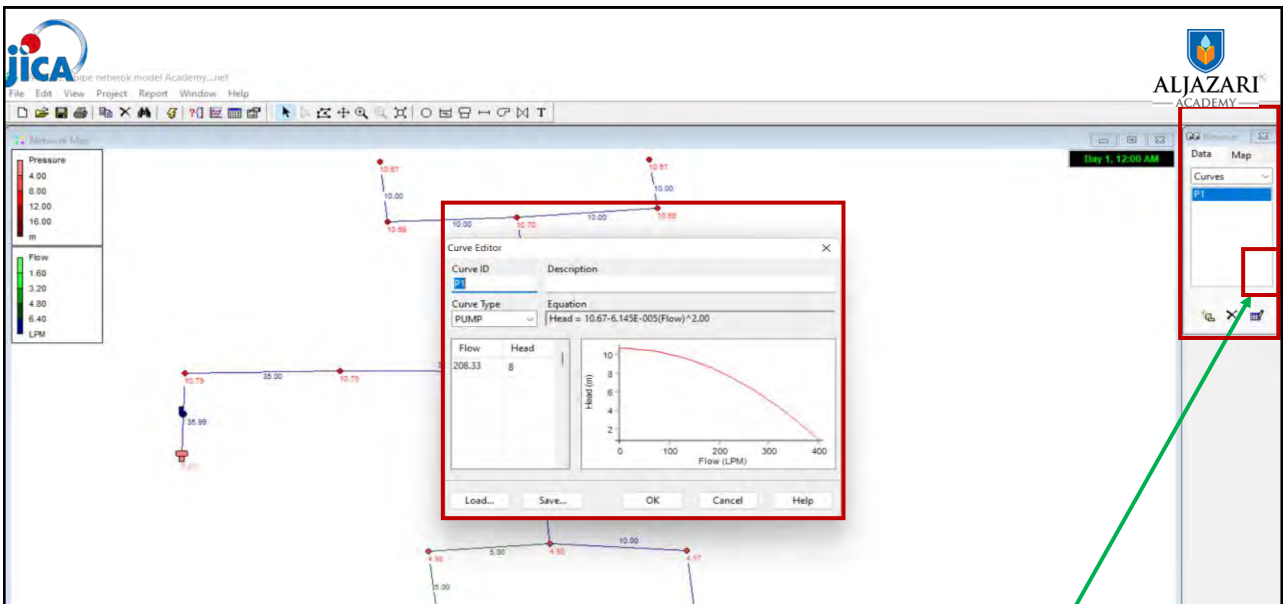



To Put parameters in reservoir we just double click on it and put the values
RESERVOIR
Reservoir 1
Property
Value
*Reservoir ID
1
X-Coordinate
-3789.00
Y-Coordinate
5676.08
Description
Tag
*Total Head
10
Head Pattern
Initial Quality
Source Quality
Net Inflow
#N/A
Elevation
#N/A
Pressure
#N/A
Quality
#N/A
Data
Map
Reservoirs

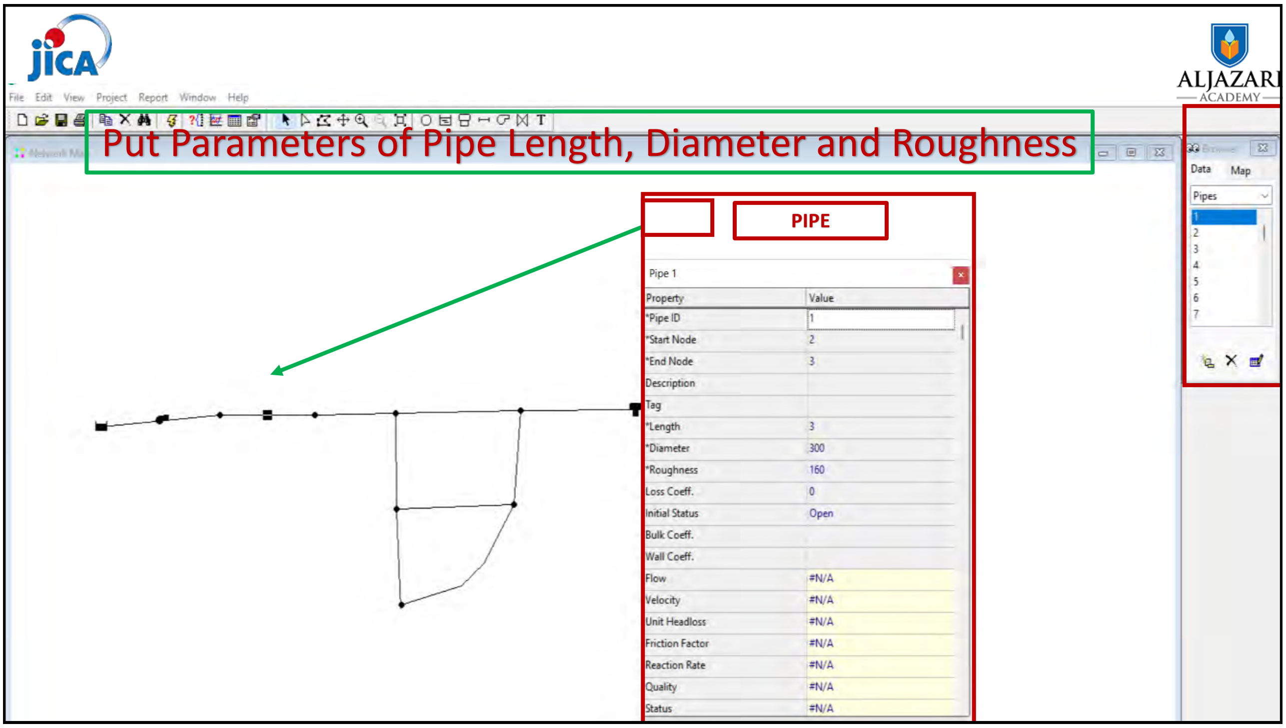

EPANET 2 - 1125.net
File Edit View Project Report Window Help
To Put parameters of pump click on pump
PUMP
Pump 9
Property
Value
*Pump ID
9
*Start Node
1
*End Node
2
Description
Tag
Pump Curve
11
Power
Speed
Pattern
Initial Status
Open
Effic. Curve
Energy Price
Price Pattern
Flow
#N/A
Headloss
#N/A
Quality
#N/A
Status
#N/A
Data
Map
Pumps

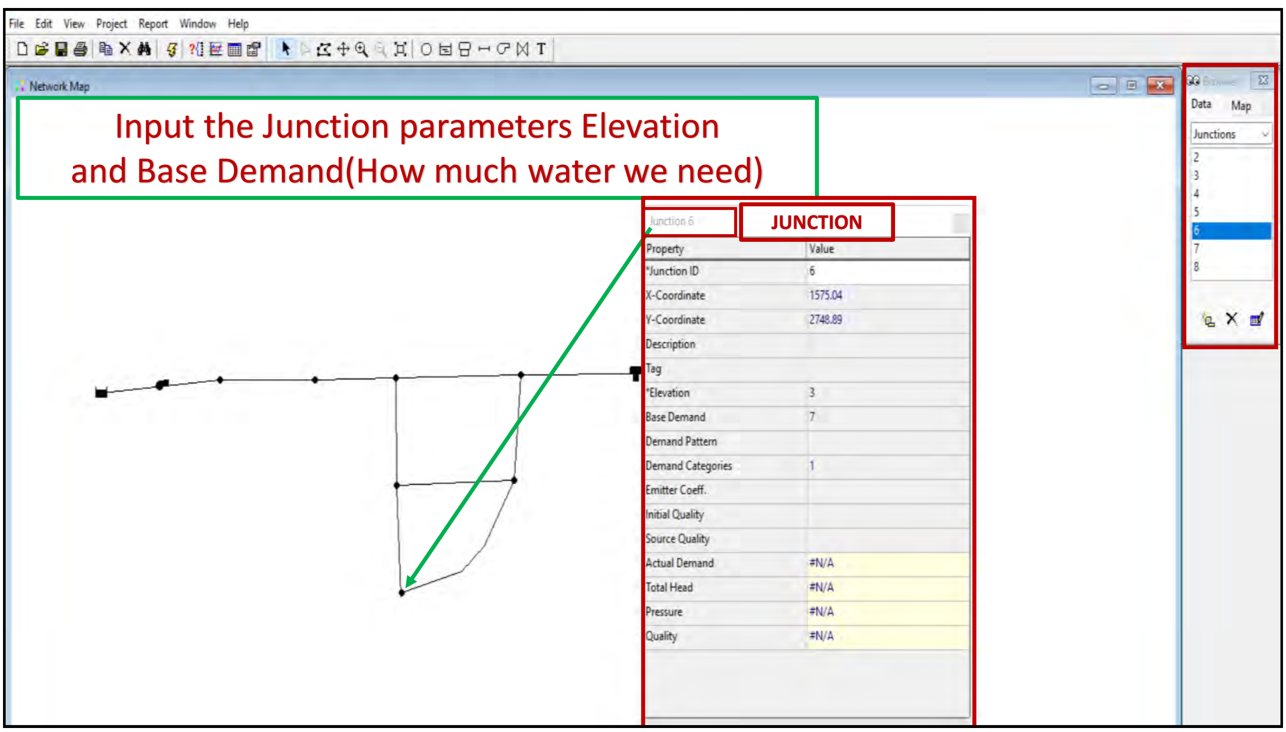


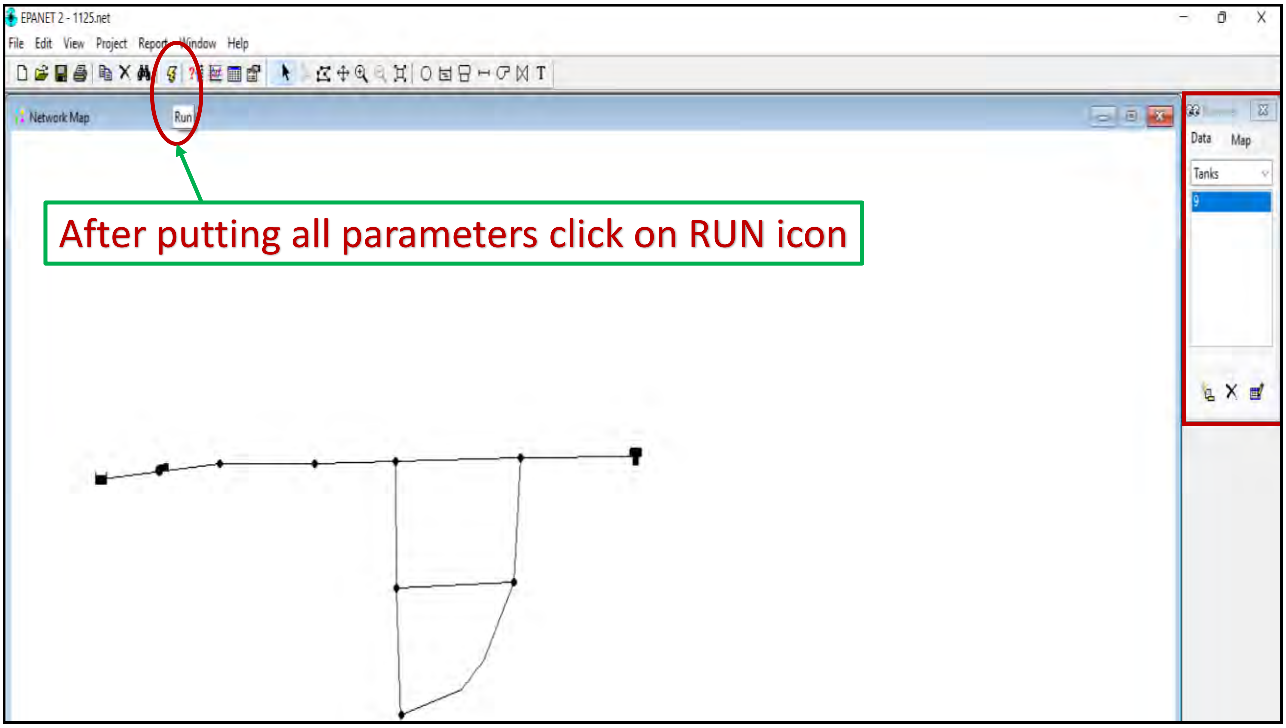
Add pump values, can add Pump curve, Power or Speed. On upper right side the different parameters we can put.

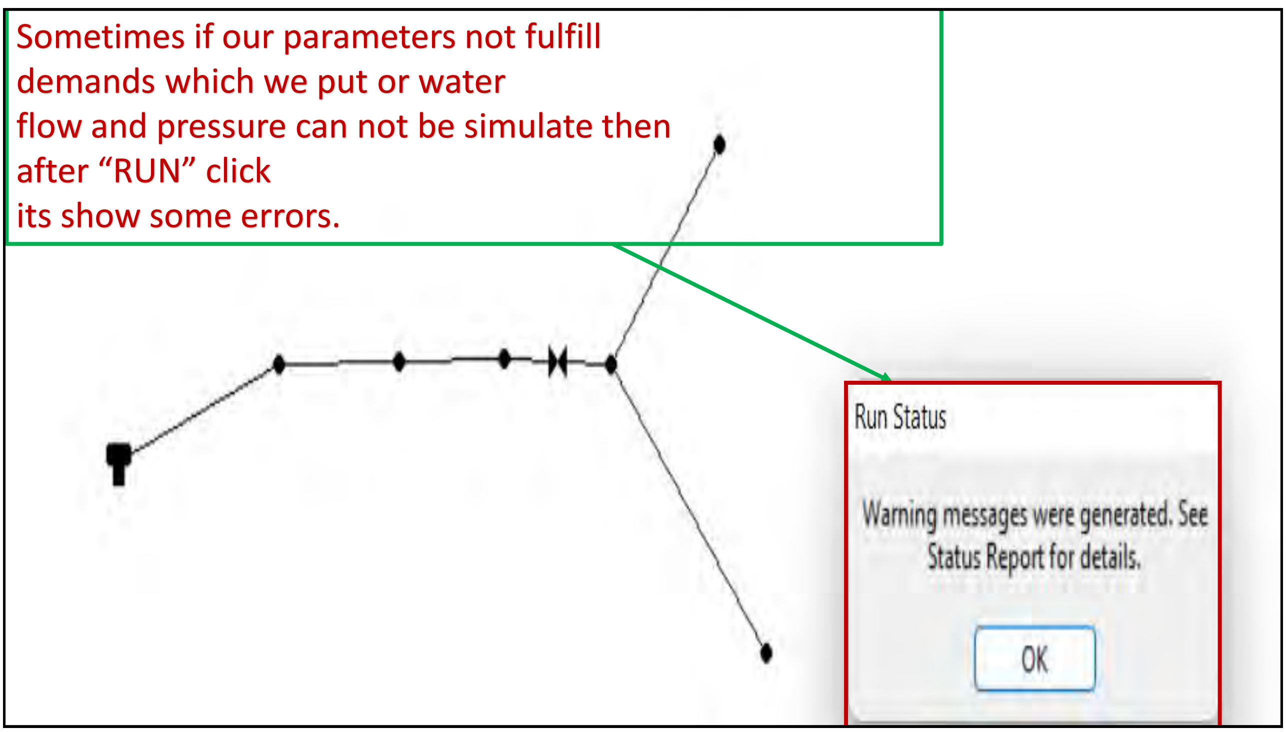


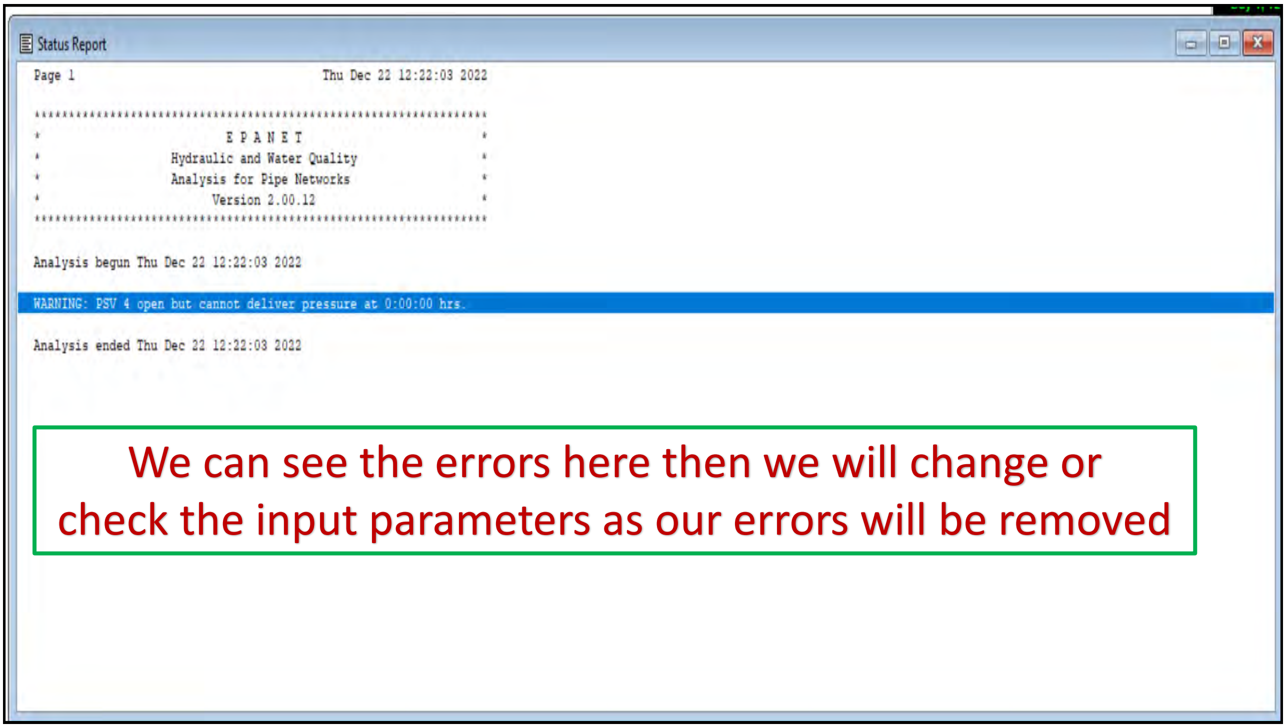
Add Pump curve, Put Flow and Head values. On upper right side click on icon and put the values.

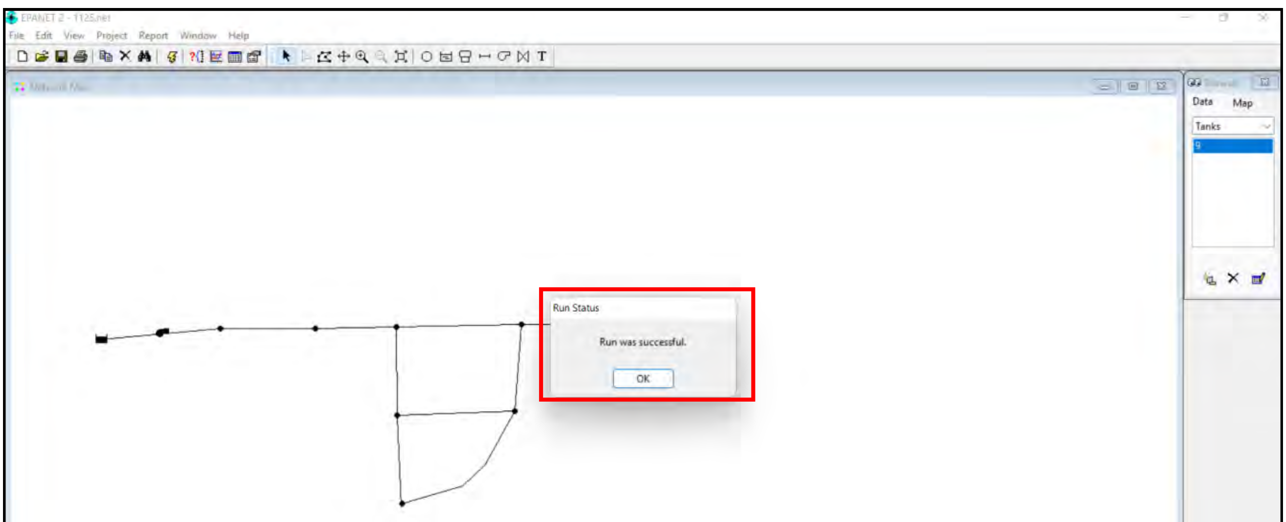

File Edit View Project Report Window Help
Put Parameters of Pipe Length, Diameter and Roughness
PIPE
Pipe 1
Property Value
*Pipe ID 1
*Start Node 2
*End Node 3
Description
Tag
*Length 3
*Diameter 300
*Roughness 160
Loss Coeff. 0
Initial Status Open
Bulk Coeff.
Wall Coeff.
Flow #N/A
Velocity #N/A
Unit Headloss #N/A
Friction Factor #N/A
Reaction Rate #N/A
Quality #N/A
Status #N/A
Data Map
Pipes
1
2
3
4
5
6
7
ALJAZARI
ACADEMY


File Edit View Project Report Window Help
Network Map
Input the Junction parameters Elevation
and Base Demand(How much water we need)
JUNCTION
Junction 6
Property Value
*Junction ID 6
X-Coordinate 1575.04
Y-Coordinate 2748.89
Description
Tag
*Elevation 3
Base Demand 7
Demand Pattern
Demand Categories 1
Emitter Coeff.
Initial Quality
Source Quality
Actual Demand #N/A
Total Head #N/A
Pressure #N/A
Quality #N/A
Data Map
Junctions
2
3
4
5
6
7
8

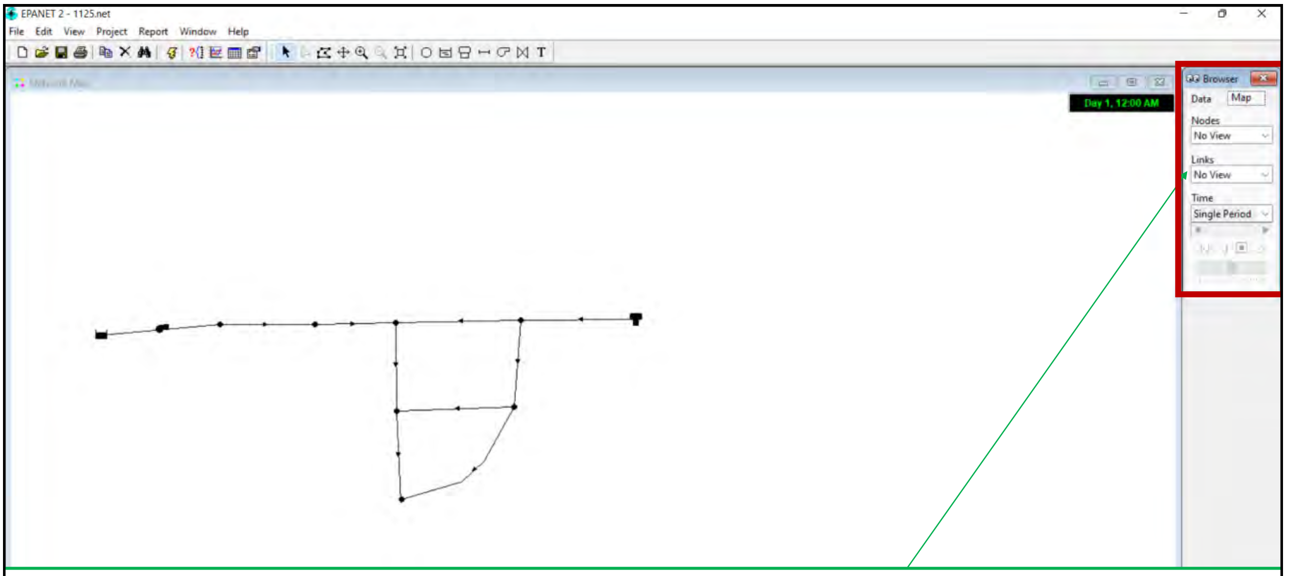

EPANET 2 - 1125.net
File Edit View Project Report Window Help
Network Map
Run
After putting all parameters click on RUN icon
Data Map
Tanks


Sometimes if our parameters not fulfill
demands which we put or water
flow and pressure can not be simulate then
after “RUN” click
its show some errors.
Run Status
Warning messages were generated. See Status Report for details.
OK

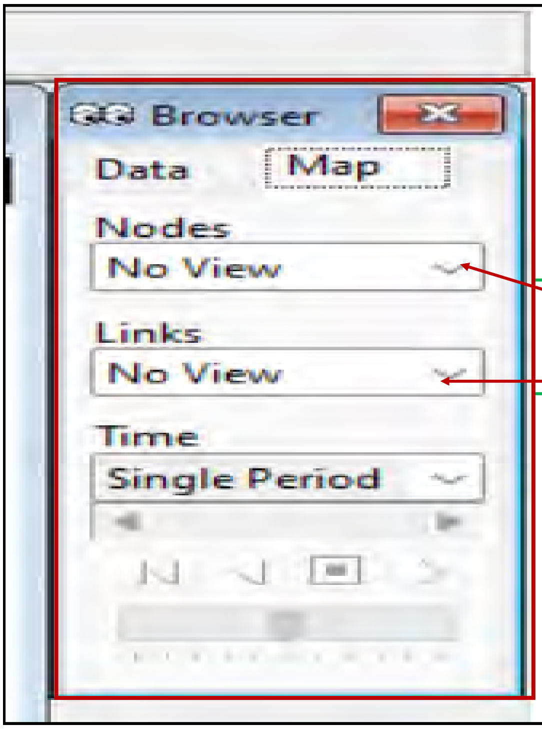




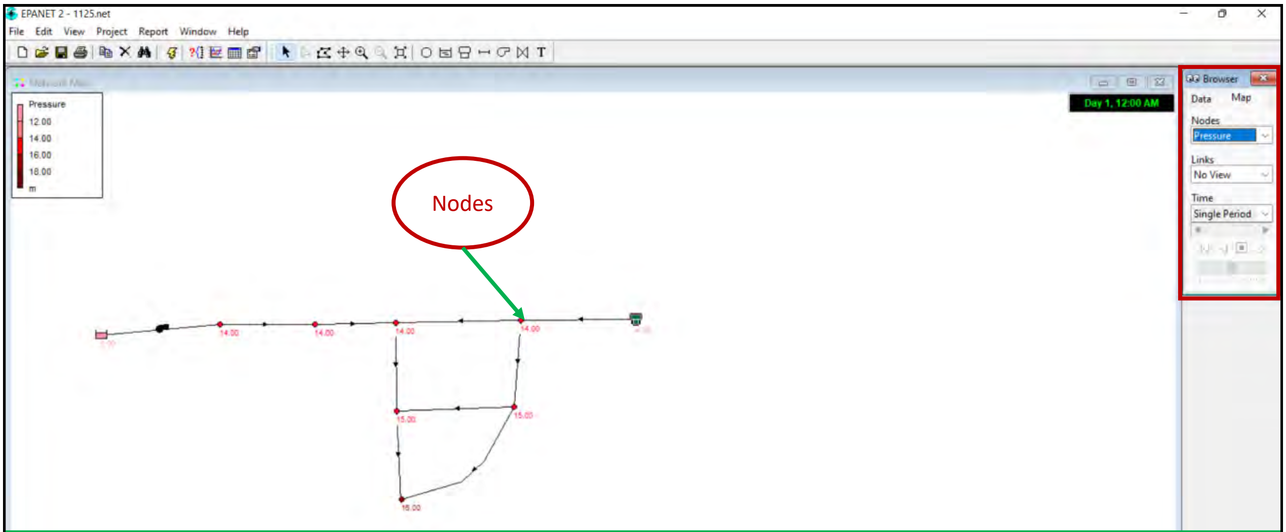
After checking input parameters and then again click on RUN Icon then status will be successful



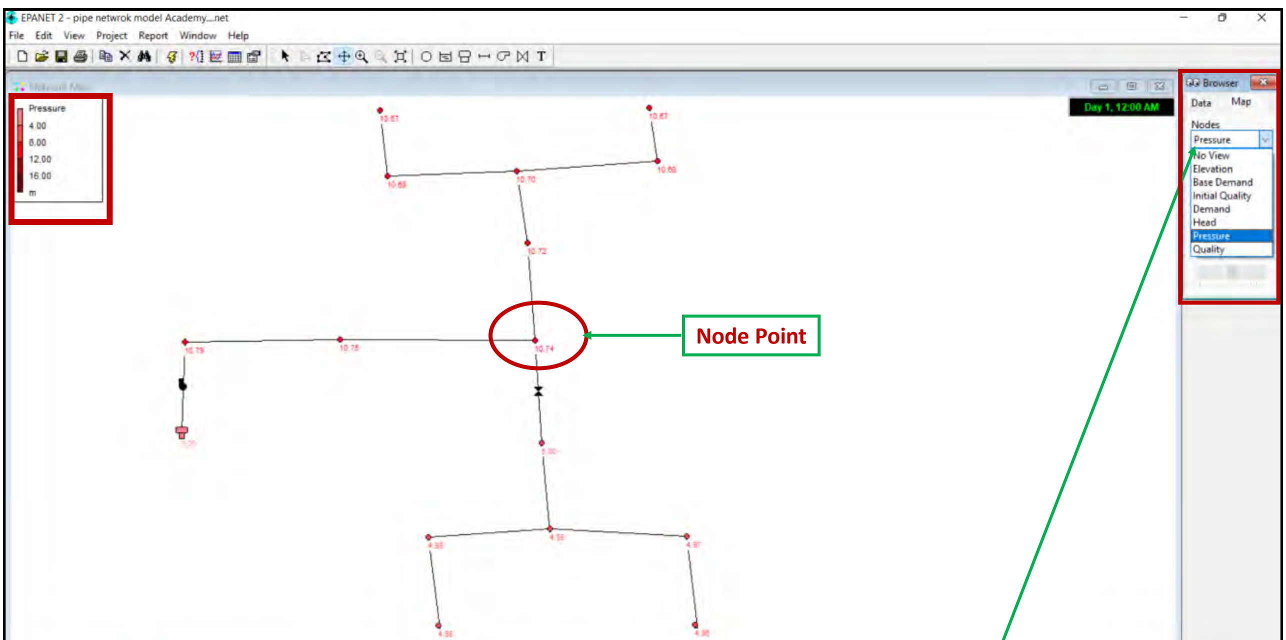
After Run Successful we have to add parameters which we want to observe



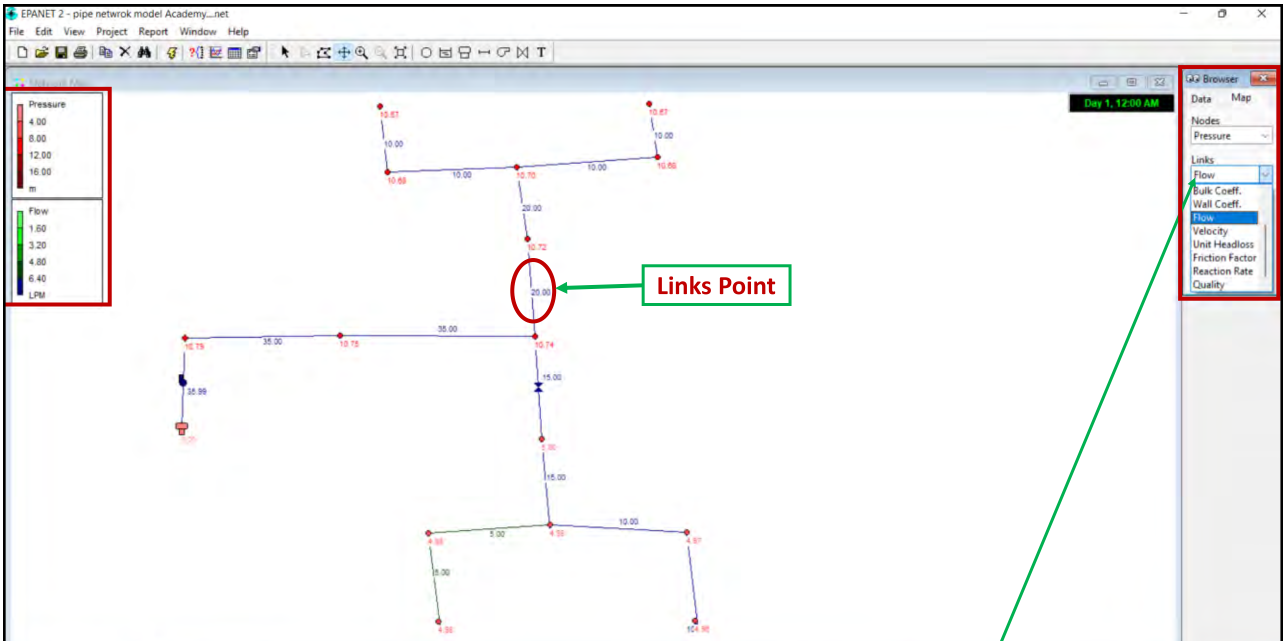
Select the Parameters of Nodes and Links and see the values



We Can observe the parameters values on "Nodes" point by clicking on right side browser Nodes



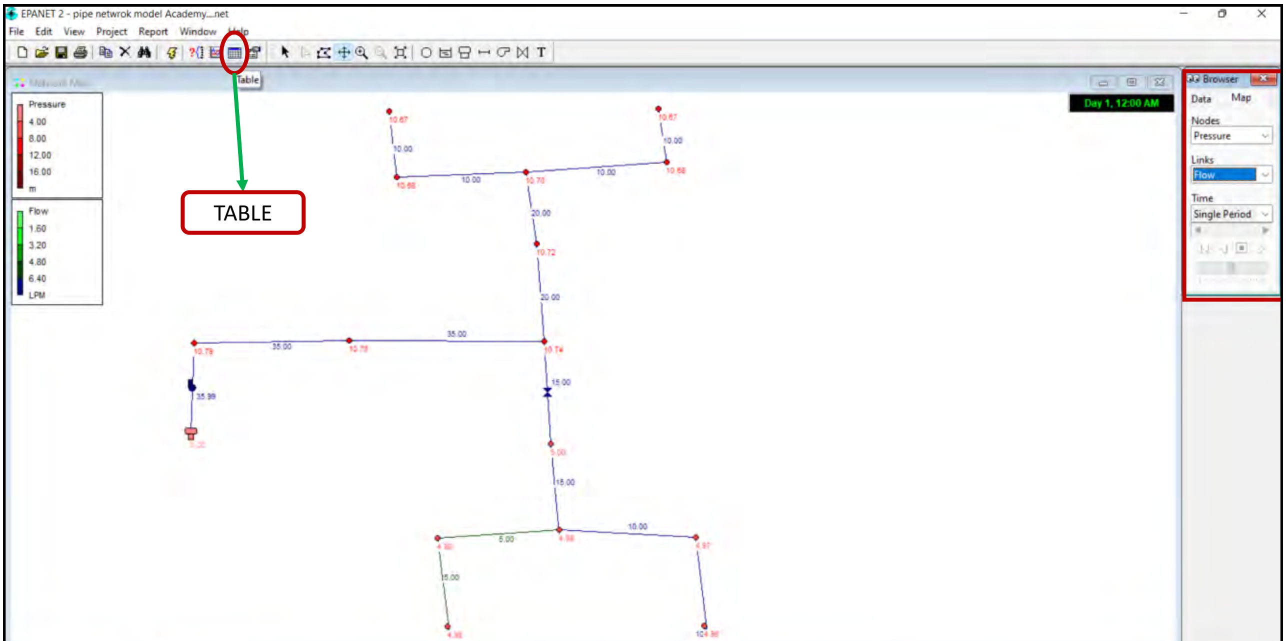
We Can observe the different parameters values on "Nodes" point by clicking on right side browser "Nodes"



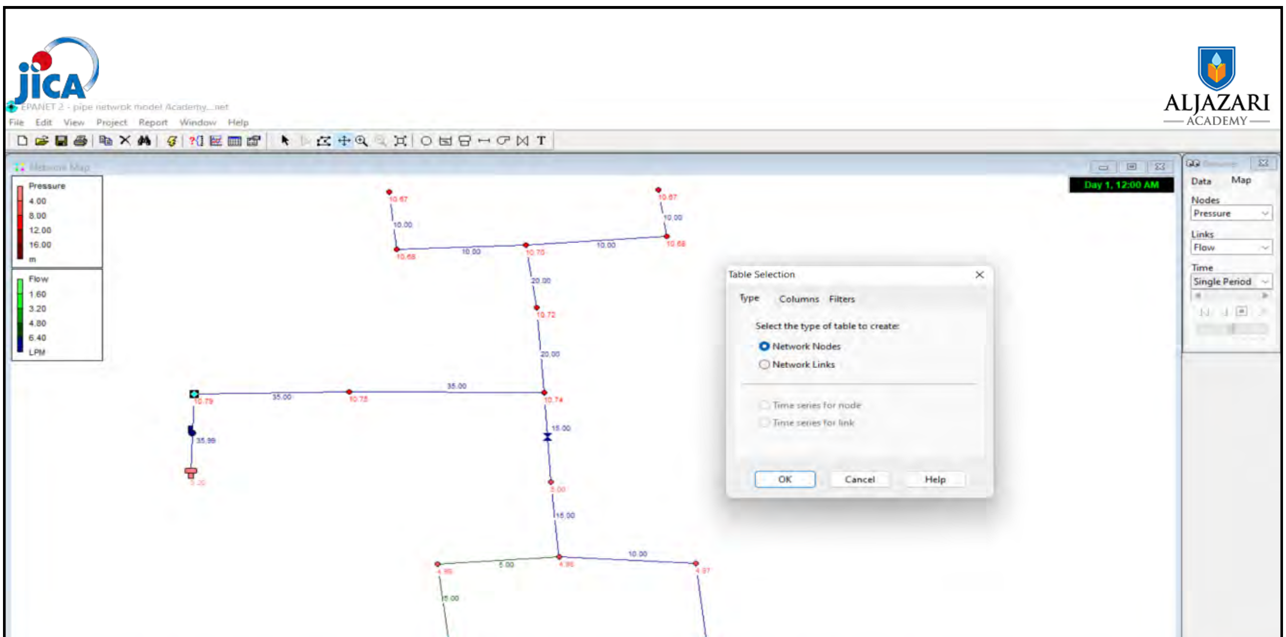
We Can observe the different parameters values on "Links" point by clicking on right side browser "Links"

Table and Charts

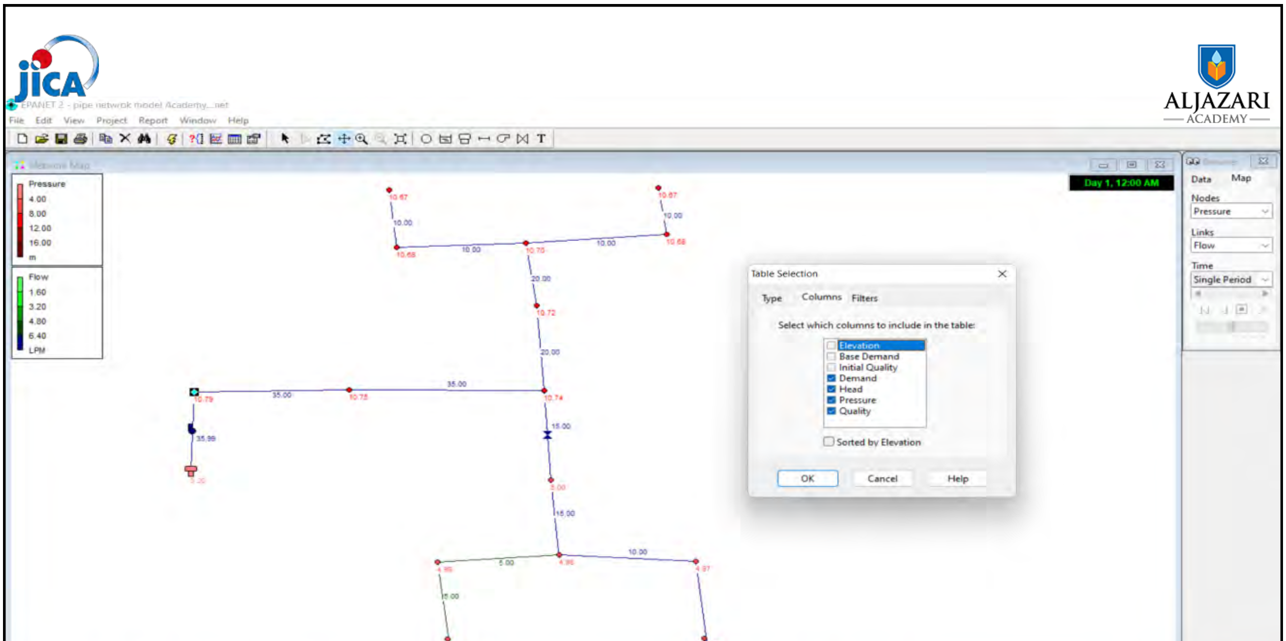
- After Successful Run and put the parameters on Node and Links point we can see results on Tables.



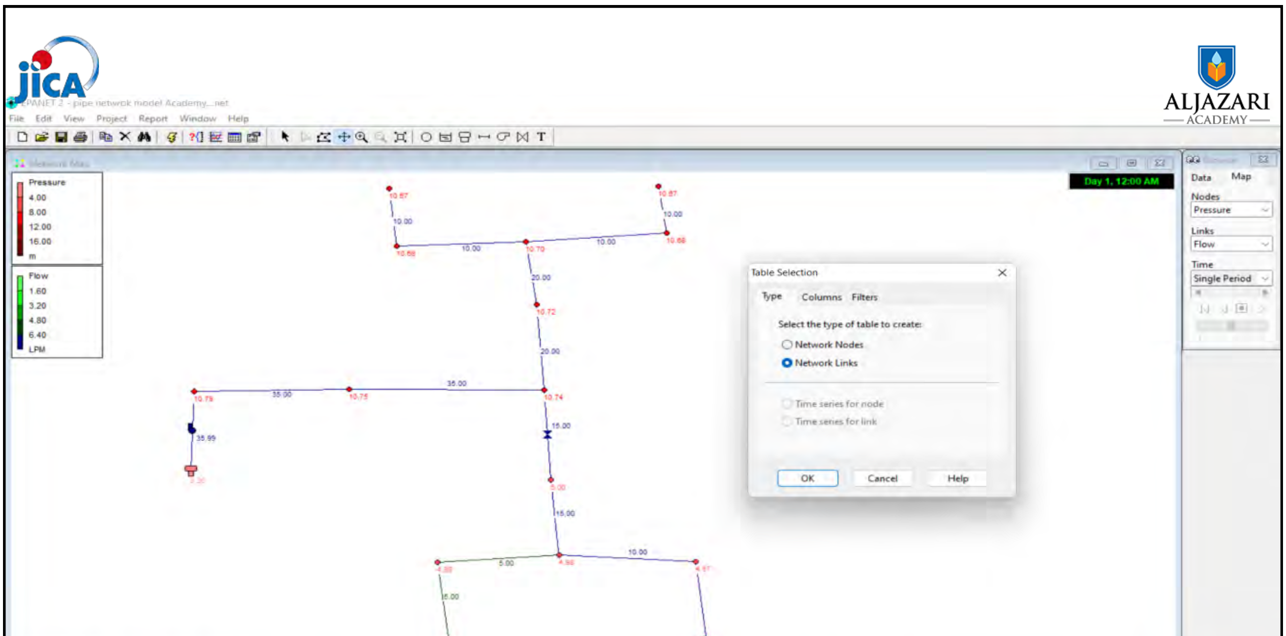
By clicking on Table ICON in toolbar a new Window will be open for Node and Links points



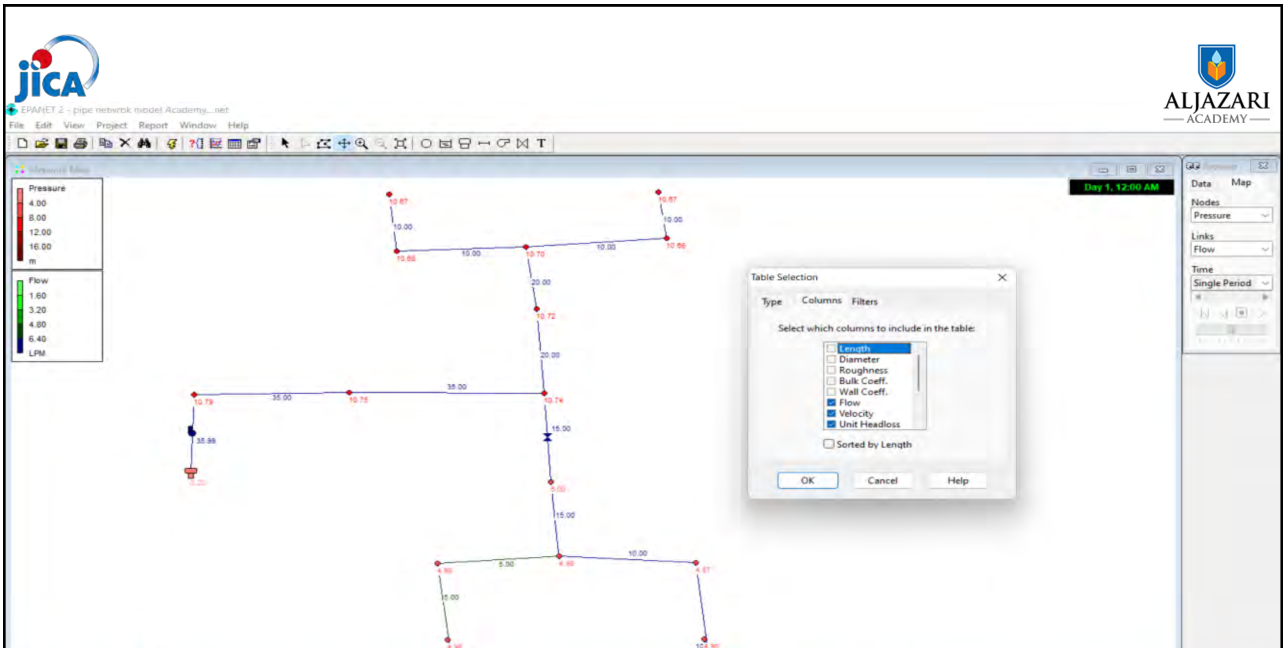
In new window we can see "Type of table creation" Can see Nodes and Links values on Table



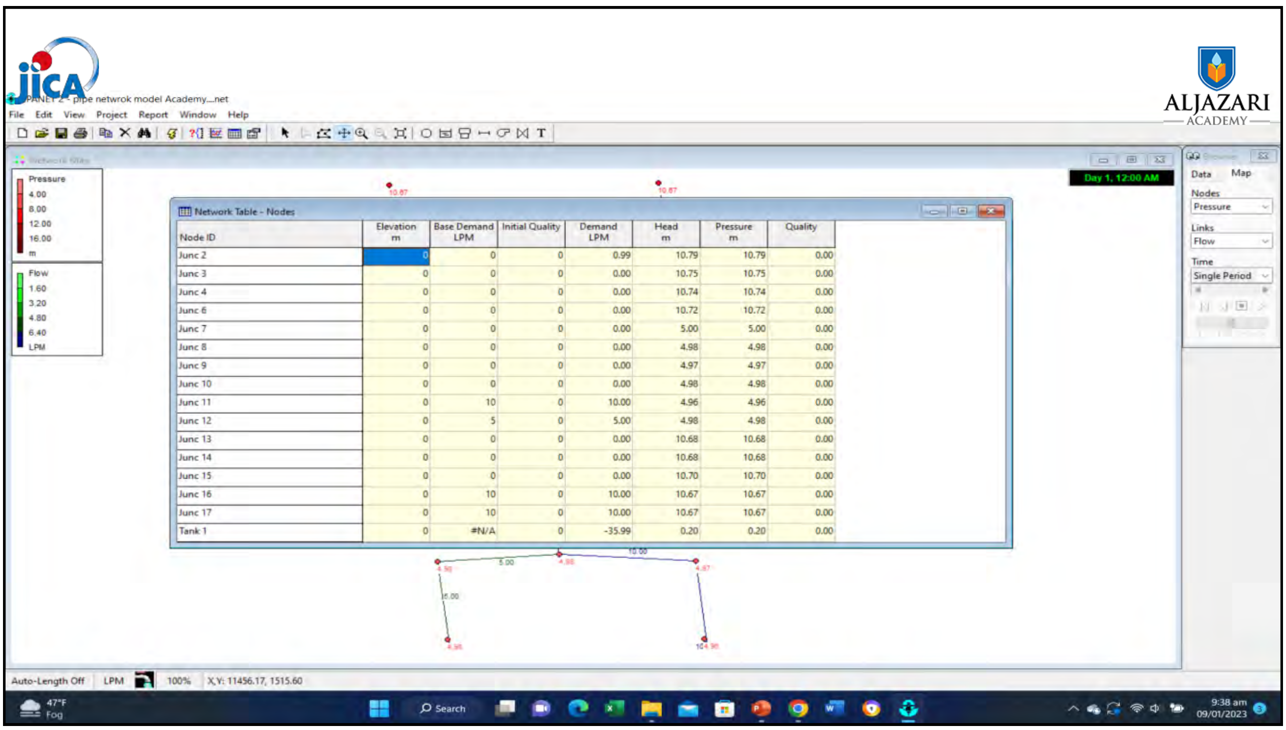
In new window we can see "Table Selection Parameters" Can select "Nodes" Points Values



In new window we can see "Table Selection Parameters" Can select "LINKS" Points Values

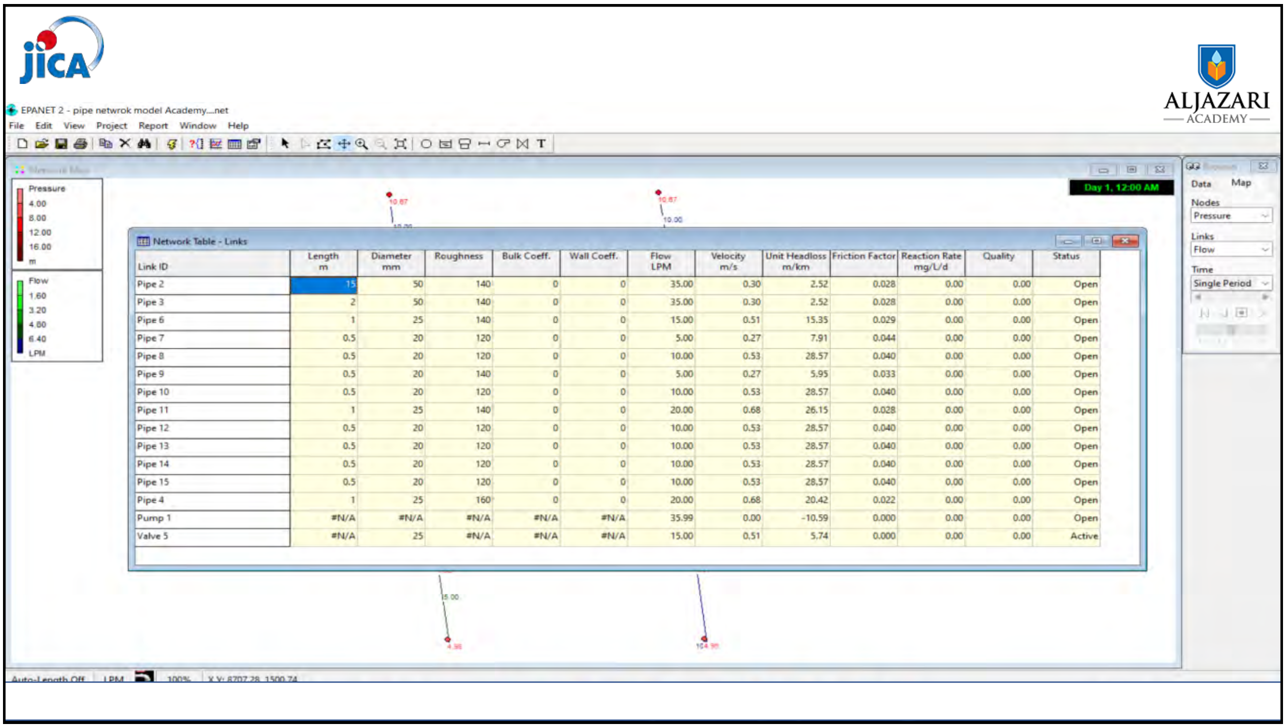


In new window we can see “Table Selection Parameters” Can select “Nodes” Points Values



Network Table - Nodes

Node ID	Elevation m	Base Demand LPM	Initial Quality	Demand LPM	Head m	Pressure m	Quality
Junc 2	0	0	0	0.99	10.79	10.79	0.00
Junc 3	0	0	0	0.00	10.75	10.75	0.00
Junc 4	0	0	0	0.00	10.74	10.74	0.00
Junc 6	0	0	0	0.00	10.72	10.72	0.00
Junc 7	0	0	0	0.00	5.00	5.00	0.00
Junc 8	0	0	0	0.00	4.98	4.98	0.00
Junc 9	0	0	0	0.00	4.97	4.97	0.00
Junc 10	0	0	0	0.00	4.98	4.98	0.00
Junc 11	0	10	0	10.00	4.96	4.96	0.00
Junc 12	0	5	0	5.00	4.98	4.98	0.00
Junc 13	0	0	0	0.00	10.68	10.68	0.00
Junc 14	0	0	0	0.00	10.68	10.68	0.00
Junc 15	0	0	0	0.00	10.70	10.70	0.00
Junc 16	0	10	0	10.00	10.67	10.67	0.00
Junc 17	0	10	0	10.00	10.67	10.67	0.00
Tank 1	0	#N/A	0	-35.99	0.20	0.20	0.00



Link ID	Length m	Diameter mm	Roughness	Bulk Coeff.	Wall Coeff.	Flow LPM	Velocity m/s	Unit Headloss m/km	Friction Factor	Reaction Rate mg/L/d	Quality	Status
Pipe 2	15	50	140	0	0	35.00	0.30	2.52	0.028	0.00	0.00	Open
Pipe 3	2	50	140	0	0	35.00	0.30	2.52	0.028	0.00	0.00	Open
Pipe 6	1	25	140	0	0	15.00	0.51	15.35	0.029	0.00	0.00	Open
Pipe 7	0.5	20	120	0	0	5.00	0.27	7.91	0.044	0.00	0.00	Open
Pipe 8	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 9	0.5	20	140	0	0	5.00	0.27	5.95	0.033	0.00	0.00	Open
Pipe 10	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 11	1	25	140	0	0	20.00	0.68	26.15	0.028	0.00	0.00	Open
Pipe 12	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 13	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 14	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 15	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 4	1	25	160	0	0	20.00	0.68	20.42	0.022	0.00	0.00	Open
Pump 1	#N/A	#N/A	#N/A	#N/A	#N/A	35.99	0.00	-10.59	0.000	0.00	0.00	Open
Valve 5	#N/A	25	#N/A	#N/A	#N/A	15.00	0.51	5.74	0.000	0.00	0.00	Active

Name:	Dept:	Designation:

1. HDPE Pipe

High density polyethylene (HDPE) piping systems have been used for municipal and industrial water applications. HDPE water pipes are made of high-density polyethylene, which is a thermoplastic polymer. Polyethylene has a number of significant advantages over traditional materials such as steel or ductile iron including lower weight, freedom from corrosion and the ability to coil long lengths of pipe.

a. Salient Features of HDPE Pipes

- Safe for drinking water with no toxic or chemical contamination.
- High flexibility. Can be bent as much as 25-40 times of the pipe diameters. Thus, reducing unnecessary pipe joint.
- Light weight with only 0.95 grams/cm2. It weighs only 1/5 of steel pipes of the same size.
- Rust proof and high resistance to damaged chemicals, making the product last up to 50 years.
- Super smooth internal surface, reducing the chance of pipe cloggage.

b. PE80 vs PE100 Comparison

Comparison of PE 100 and PE 80 HDPE Pipes
▪ Before international standards were adopted polyethylene (PE) materials were commonly named by their density - low density, medium density and high density. ISO standards were further developed to designate materials as PE80 or PE100 to easier differentiate the benefits of the materials. ▪ PE80 pipes are often rated SDR11 PN12 and have a minimum required strength (MRS) of 8 MPa (Megapascal) whereas PE100 pipes are rated SDR11 PN16 and have a MRS of 10 Mpa. ▪ PE100 offers additional long-term strength and performance over PE80 while allowing for thinner pipe walls for the same operating pressure.

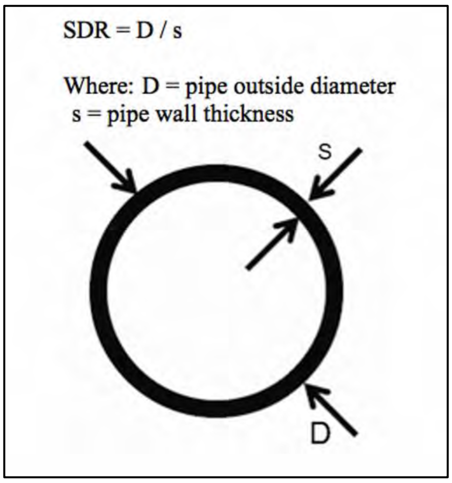
c. HDPE pipes color code guide:

Red	Electric power lines, cable, conduit and lighting cables
Orange	Telecommunication, alarm or signal lines, cables or conduit
Yellow	Fuel gas (methane or propane), oil, petroleum, steam or gaseous materials
Green	Sewers and drain lines
Blue	Potable water
Violet (Purple)	Reclaimed water, irrigation and slurry lines

Name:	Dept:	Designation:

2. HDPE Pipe Parameters

a. Standard Dimension Ratio (SDR)



Standard dimension ratio (SDR) is a method of rating a pipe's durability against pressure.

SDR= D/s

Where;

D= Outside diameter of pipe

S= Thickness of pipe

It's an inverse relationship. The higher the SDR, the lower the pressure rating.

b. In HDPE Pipe terms, MRS stands for "Minimum Required Strength" (MRS).

The MRS is determined by performing regression analysis in accordance with ISO 9080 on the test data from the results of long-term pressure testing.

Material Designation	Minimum Required Strength (MRS)MPa
PE100	10.0
PE80	8.0

Another parameter is defined as the 'Maximum Operating Pressure' MOP, or the pressure rating of the pipe.

MOP = 2 x MRS / C (SDR - 1) ---- Where MRS and MOP are in MPa

MOP = 20 x MRS / C (SDR - 1) ----- Where MRS is in MPa and MOP is in bar.

Where C is the 'overall service (design) coefficient, or Safety Factor.

For water applications the minimum value of C is 1.25

Name:	Dept:	Designation:

c. Pressure Reduction Factor

Table 1 — Pressure reduction factors for temperatures between 20 °C and 50 °C

Material classification	Pressure reduction factors[a b]						
	20 °C	25 °C	30 °C	35 °C	40 °C	45 °C	50 °C
PE 100 PE 80	1,00	0,92	0,85	0,79	0,73	0,67	0,63
PE 63	1,00	0,92	0,85	0,79	0,73		
PE 40	1,00	0,92	0,85	0,77	0,70		

[a] Reference to ISO 9080:2012 shall be made for extrapolation time limits, see 5.3.

[b] The ISO 9080:2012 extrapolation factors are 50 for 40 °C, 30 for 45 °C and 18 for 50 °C when the material is tested at a maximum temperature of 80 °C. If the material is tested at a higher temperature than 80 °C then other extrapolation factors may apply.

3. Available Sizes of PE 100 pipes

Dimension Ratio	SDR21	SDR17	SDR 13.6	SDR11
	PN8	PN10	PN 12.5	PN16
OUTSIDE DIAMETER (mm)	Wall Thickness (mm)	Wall Thickness (mm)	Wall Thickness (mm)	Wall Thickness (mm)
20	-	-		2.0
25	-	-	2.0	2.3
32	-	2.0	2.4	3.0
40	2.0	2.4	3.0	3.7
50	2.4	3.0	3.7	4.6
63	3.0	3.8	4.7	5.8
75	3.6	4.5	5.6	6.8
90	4.3	5.4	6.7	8.2
110	5.3	6.6	8.1	10.0
125	6.0	7.4	9.2	11.4
140	6.7	8.3	10.3	12.7
160	7.7	9.5	11.8	14.6
180	8.6	10.7	13.3	16.4
200	9.6	11.9	14.7	18.2
225	10.8	13.4	16.6	20.5
250	11.9	14.8	18.1	22.7
280	13.4	16.6	20.6	25.4
315	15.0	18.7	23.2	28.6
355	16.9	21.1	26.1	32.2
400	19.1	23.7	29.4	36.3
450	21.5	26.7	33.1	40.9

Name:	Dept:	Designation:

HDPE Pipe Parameters – Class Activity 1

Diameter (mm)	Thickness (mm)	SDR	MOP (bar)	Avg. Temperature in your area	Temperature Factor (From table 1)	Effective MOP (bar)

	Unit	Labour	Composite	Unit	Labour	Composite
c) PN-10 (SDR-17)						
i) 90 mm	P.Rft	4.60	240.85	PM	12.55	790.25
ii) 110 mm	P.Rft	12.85	364.65	PM	35.10	1,196.45
iii) 125 mm	P.Rft	14.20	463.00	PM	38.80	1,519.05
iv) 160 mm	P.Rft	15.60	752.25	PM	42.65	2,468.20
v) 180 mm	P.Rft	20.00	951.85	PM	54.70	3,122.95
vi) 200 mm	P.Rft	22.35	1,172.85	PM	61.10	3,848.15
vii) 225 mm	P.Rft	25.50	1,486.00	PM	69.70	4,875.65
viii) 250 mm	P.Rft	35.20	1,824.55	PM	96.30	5,986.40
ix) 315 mm	P.Rft	62.45	2,904.80	PM	170.70	9,530.70
x) 355 mm	P.Rft	69.45	3,688.60	PM	189.85	12,102.25
xi) 400 mm	P.Rft	78.60	4,654.90	PM	214.95	15,272.70
xii) 450 mm	P.Rft	79.85	5,888.40	PM	218.40	19,319.85
xiii) 500 mm	P.Rft	94.05	7,281.95	PM	257.10	23,892.05
xiv) 560 mm	P.Rft	104.40	9,138.50	PM	285.40	29,983.35
xv) 630 mm	P.Rft	117.10	11,537.95	PM	320.15	37,856.00
xvi) 710 mm	P.Rft	132.65	14,684.75	PM	362.65	48,180.60
xvii) 800 mm	P.Rft	150.45	18,566.10	PM	411.30	60,915.35
xviii) 900 mm	P.Rft	189.25	23,593.55	PM	517.45	77,410.35
xix) 1000 mm	P.Rft	219.70	29,119.95	PM	600.70	95,542.55

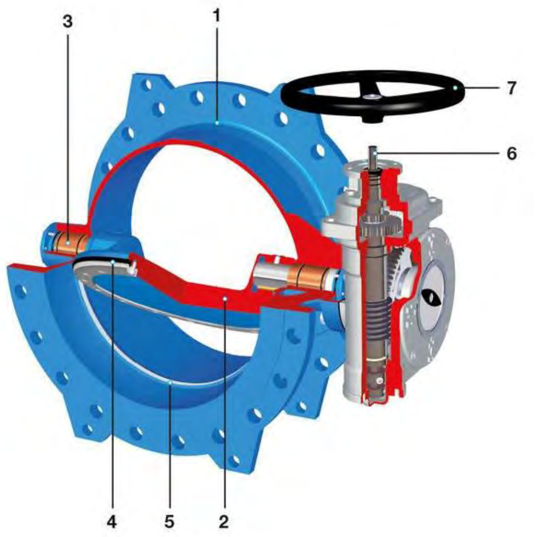
PN Rating	Diameter	Length	Unit Cost (Composite-Labour)	Total Cost
PN 10		**100 ft**		

Name:	Dept:	Designation:

Valves – Class Activity 2

i. Label the picture displayed below according to the numbers:

No.	Labelling
1	
2	
3	
4	
5	
6	



ii. Choose the correct answers.

a) Non-return valve or check valve is used for?

( ) To reverse the flow ( ) To prevent reverse flow ( ) To stop the flow

b) Which type of valve is recommended to use for isolation?

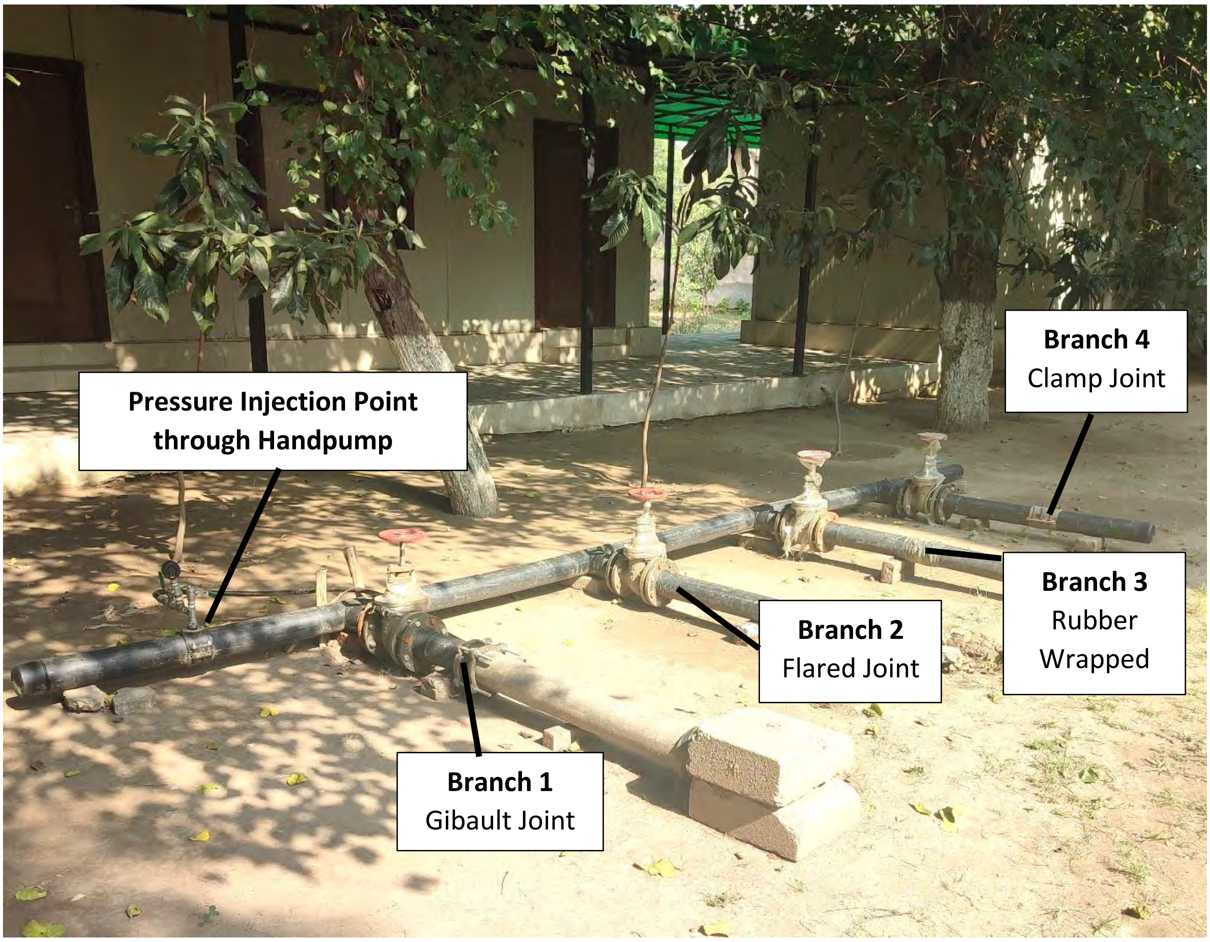
( ) Sluice/gate valve ( ) Butterfly valve ( ) Air release valve

c) Air release valve are used for?

( ) To release entrapped air ( ) To pump air ( ) Both

Name:	**Dept:**	**Designation:**

4. Hydrostatic Pressure Test Activity for HDPE Pipe



Instructions:

- Setting the Optimum Pressure for Test: Working pressure of Pipe x 1.5
- Time Duration: 10 mins (2 hours as recommended in the standard)
- Hazard Awareness: Participants are advised to keep a distance from potential leakage joint or valve
- Fill the pipe with water by connecting to the nearby source until water come out on the other end. For the releasing air, we can use air valve.
- Pressurizing: Inject the water with the help of hand pump to build a pressure inside pipes up to desired pressure rating.
- Observe the joints and valves for leakages. If any leakage appears, note the reading on pressure gauge.
- Keep pressuring branch wise until setting pressure and close valve, Start counting time.
- If no leakage appears after holding the optimum pressure for specified time, the joint is considered valid.

Name:	**Dept:**	**Designation:**

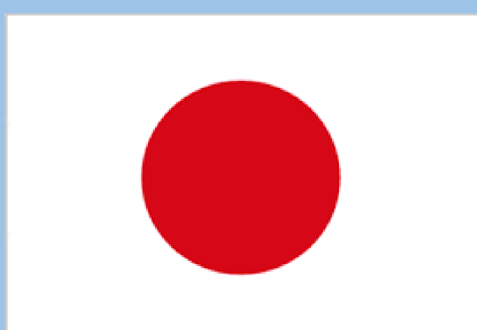
Hydrostatic Pressure Testing – Class Activity 3

Participants to perform the pressure test activity and observe the leakages and corresponding pressure ratings.

Leakage Point	Pressure	Reliability (Low, Medium, High)
Branch 1 – Gibault Joint		
Branch 2 – Flared Joint		
Branch 3 – Rubber Tube		
Branch 4 – Clamp Joint		

Annex 5.1.53 Training Material for "O&M of Sewerage and Drainage" in Spring 2023

In the name of Allah, the most Gracious and ever Merciful



Introduction

Welcome To All Stakeholders

Introduction

Course Team

Mr. Tomidokoro	JICA Expert
Mr. Syed Fahad Hussain	Course Leader Sewerage & Drainage System
Mr. Muhammad Irfan	Specialist Infrastructure
Mr. Uzair Safdar	Instructor

Introduction

Operation and Maintenance (O&M) of Sewerage and Drainage System

Code: S 3221

Modules 03

Duration 03 Days

Class Work
Field Work

Introduction

Modules

Module 1
- Cleaning of Sewerage & Drainage Pipelines
- 01 Day

Module 2
- Flow Measurement
- 01 Day

Module 3
- Wastewater Testing & Flow Rate Measurement
- 01 Day

Introduction

WHAT WILL ANIMATE THE TRAINING SESSION. . .

- Mini Lectures
- Video Clips
- Discussions
- On-Site-Training
- Case Histories
- Q&A
- Presentations

Introduction

INSPECTION OF SEWER / MANHOLE

Objectives of Sewer Inspection

- To identify existing or potential problems in Sewer / Manhole
- To examine structure of the Sewer / manhole
- To observe functional capacity of Sewer / manhole

INSPECTION METHODS

- Visual
- Camera

Visual Inspection

Arrangements before Inspection:

• Map of the Collection System	• Scrapers and Wire Brushes for Cleaning the Manhole Ring
• Metal Detector	• Powerful Flashlight
• Warning Devices, Safety Cones and Traffic Safety Devices	• Gas Detection Devices
• Manhole Lid Removal Device	• Blower and Hose for Ventilating Manhole
• Leather Gloves	










Categories of Visual Inspection…

Initial Inspection

- Location
- Manhole Cover
- Ring & Frame
- Manhole Material
- Sizes

Structural Inspection

- Steps
- Cone
- Riser
- Shelf
- Channel

Hydraulic Inspection

- Inflow
- Clarity
- Flow
- Flow Depth
- Vermin

¼ SEC. #: SANITARY SEWER MANHOLE INSPECTION FORM

M.H. DEPTH: FORM: M.H. #: DATE:

I. INITIAL INSPECTION

A. LOCATION:
1. Roadway
2. Gutter
3. Paved Alley
4. Unpaved Alley
5. Easement
6. Other

B. MANHOLE COVER:
1. Serviceable
2. Damaged
3. Displaced
4. Missing Grout
5. Needs Raising
6. Needs Lowering

C. RING & FRAME:
1. Serviceable
2. Loose
3. Displaced
4. Missing Grout
5. Needs Raising
6. Needs Lowering

D. MANHOLE MATERIAL:
1. Brick
2. Concrete

E. SIZE M.H. COVER:
1. 24 Inch
2. 30 Inch

F. MANHOLE SIZE:
1. 4 foot
2. 5 foot

II. STRUCTURAL INSPECTION

A. STEPS:
1. Serviceable
2. Unsafe
3. Missing (No.)
4. Corroded

B. CONE:
1. Serviceable
2. Broken
3. Sulfided
4. Misaligned
5. Leaking/Bad Joints

C. RISER:
1. Serviceable
2. Broken
3. Sulfided
4. Misaligned
5. Leaking/Bad Joints

D. SHELF:
1. Serviceable
2. Broken
3. Dirty
4. Sulfided
5. Bad Base Joint

E. CHANNEL:
1. Serviceable
2. Obstructed
3. Sulfided
4. Bad Pipe Joint
5. Silt
6. Poor Struct. Cond.

III. HYDRAULIC INSPECTION

A. INFLOW INDICATIONS:
1. Debris on Sides/ Shelf

B. SURCHARGE INDICATIONS:
1. Grease/Debris on Sides & Shelf

C. CLARITY OF FLOW:
1. Turbid Appearance
2. Clear Appearance

D. FLOW:
1. Steady
2. Pulsing
3. Turbulent
4. Surcharging
5. Sluggish

E. FLOW DEPTH COMPARED TO ADJACENT MANHOLES:
1. Same
2. Lower
3. Higher

F. FLOW DEPTH:

__________ Inches

Time ________ AM/PM

IV. VERMIN
1. Roaches
2. Rats
3. Other

OBSERVATION SUMMARY:

Manhole Inspection Form

Screening Camera For Sewer Inspection

Objectives of Screening Camera

1. To look for damages / breaks in sewer line
2. To locate root intrusion
3. To find unrecorded connection
4. To locate protruding laterals
5. To locate cracks / inflow sources
6. To search lost / buried lines
7. To verify alignment

Components of Camera

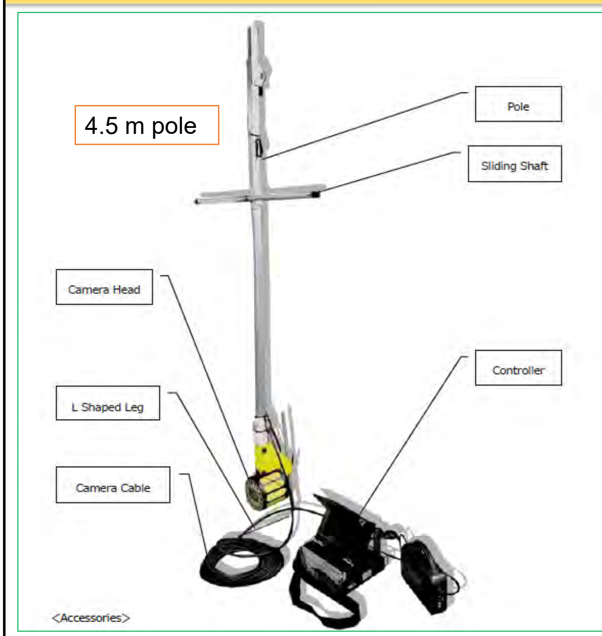
System

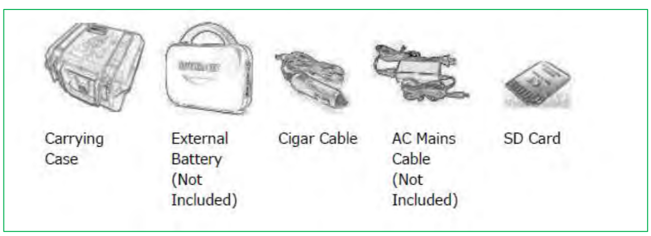
1) Camera Head .... 1 pc
2) Camera Cable (10m) .... 1 pc
3) Controller .... 1 pc
4) Pole (4.5m : 3-stage telescopic) .... 1 pc

Accessories

1) Carrying Case .... 1 pc
2) SD Card .... 1 pc
3) Cigar Cable .... 1 pc
4) AC Mains Cable .... 1 pc
5) Instruction Manual (this document) .... 1 pc

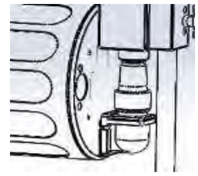
Components of Camera

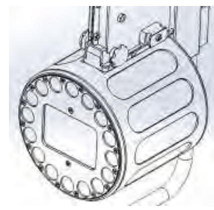




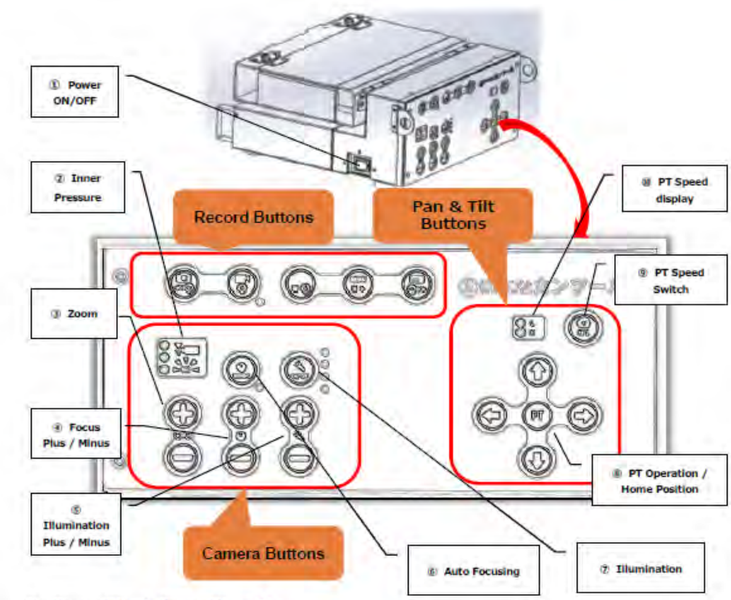
How to Connect Device

1. Take out the camera head and the camera cable from the carrying case.
2. Connect the camera head to the camera cable
3. Take out the controller from the carrying case.
4. Connect the controller to the camera cable.
5. Connect the pole to the camera head



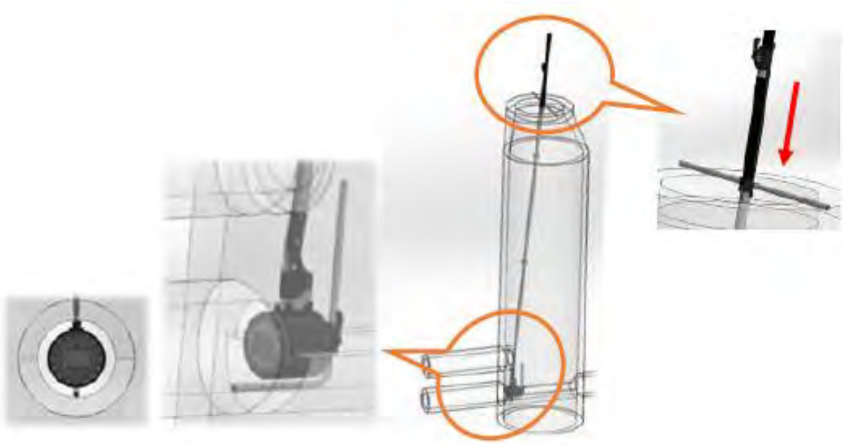


How to Operate (Overview)



① Power ON: I Power OFF: O

Installation into the Manhole



Recording (Video/Still Image)

Video recording time (estimate)

Picture quality	4GB	8GB	16GB	32GB
Highest	About 48 min	About 96 min	About 190 min	About 380 min
High	About 60 min	About 120 min	About 240 min	About 480 min
Normal	About 80 min	About 160 min	About 320 min	About 640 min

WASA Rawalpindi (Pictures)

mWater App
&
QGIS Software

Instructor

Engr. Muhammad Uzair Safdar

Learning Objectives

- **Learning** key features of M-Water App/Portal and Q-GIS software and its application in Sewerage & Drainage activities
- **Creating** data collection forms related to different assets of water utility i.e Crown Failure, Desilting activity, sewerage Overflow etc
- **Using** M-Water App in field for Data Collection and Management related to sewerage activities
- **Presentation and visualization of** recorded data in Q-GIS Program

Learning Outcomes

Visualization in mWater Portal

- Quick check of the data

Excel

- Integrate and conserve all the data, calculate and analyze etc..

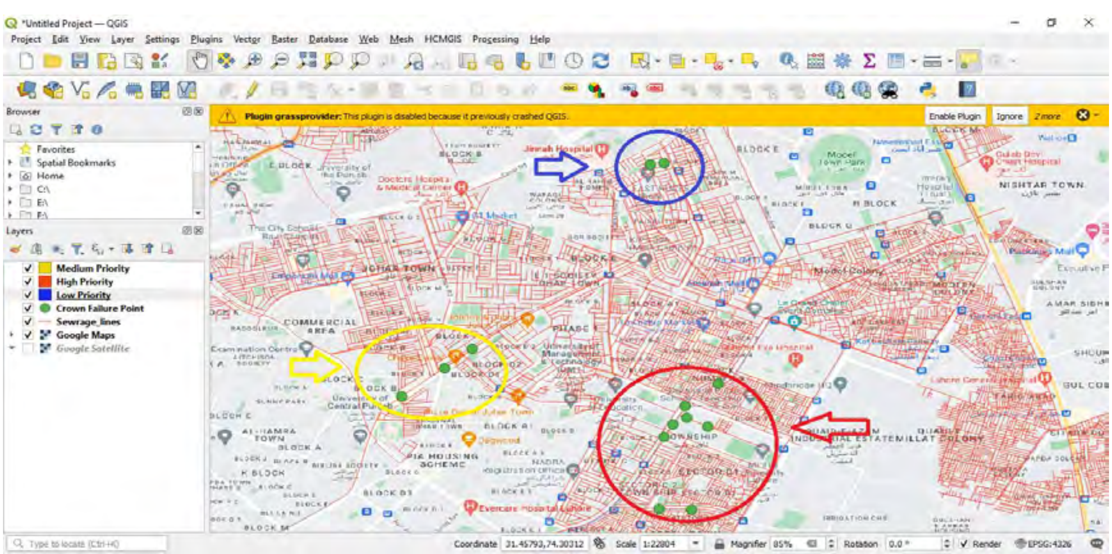
QGIS

- Visualize data on map and express the parameter as you like
- **Prioritize** the area for budget allocation for replacement etc.

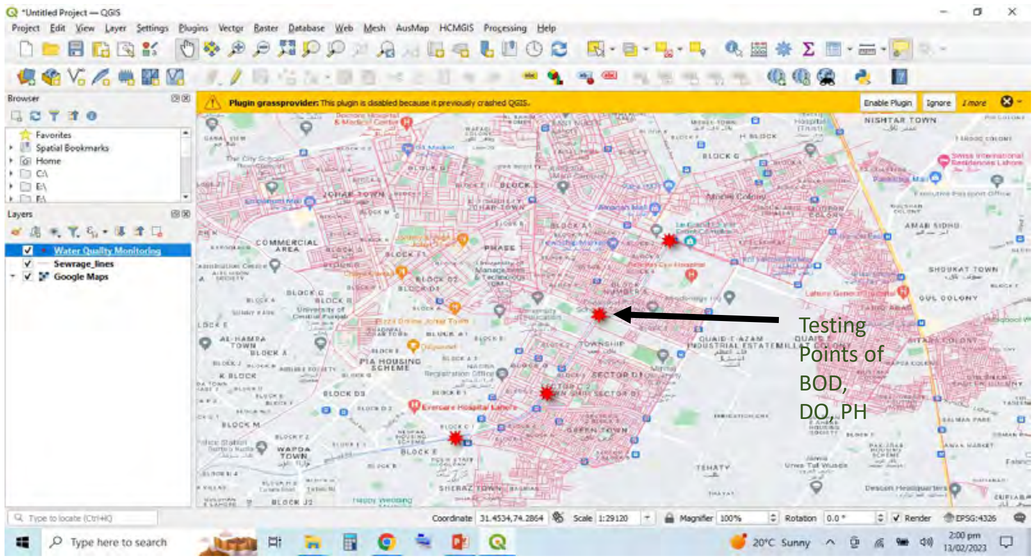
→ Exhibit the crown failure situation effectively

- Request budget from the Government
- Attract international fund

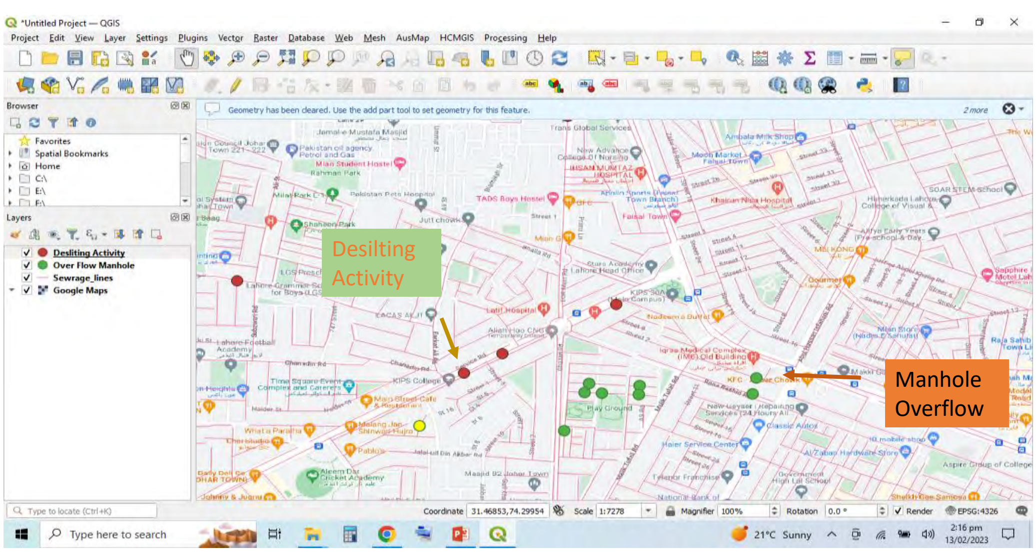
Prioritization Planning: Crown Failure



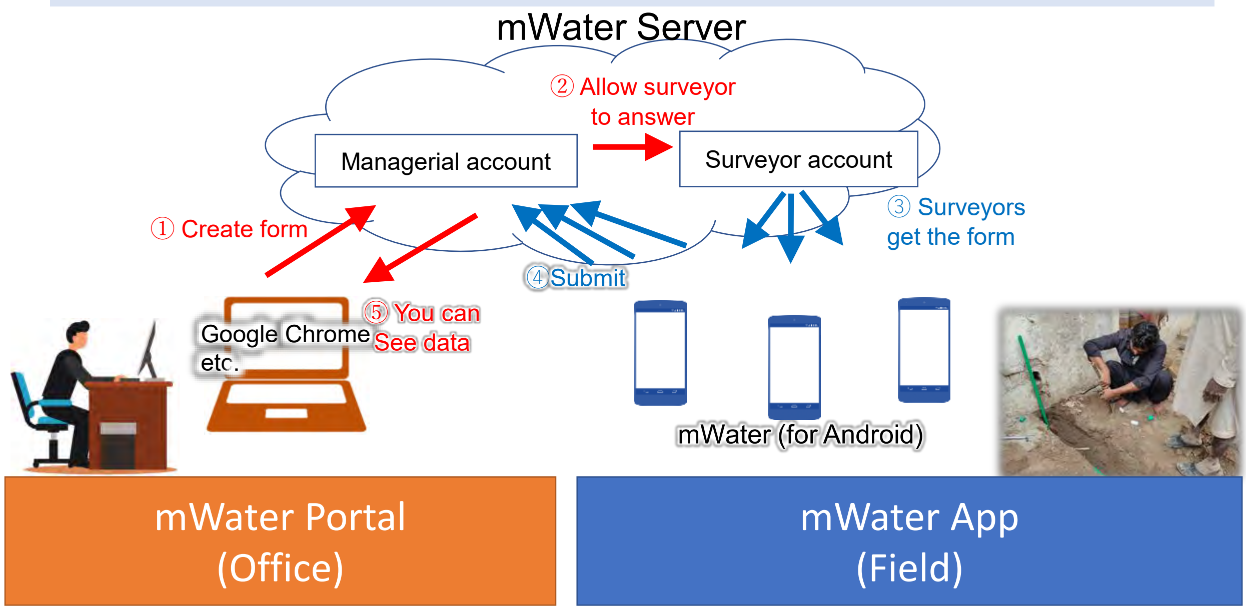
Water Quality Monitoring(BOD, DO, PH)



Overflow Manhole and Desilting Activity Monitoring



mWater data collection

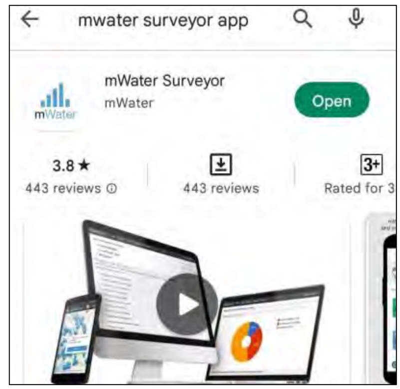


mWater App

(for Android)

mWater App

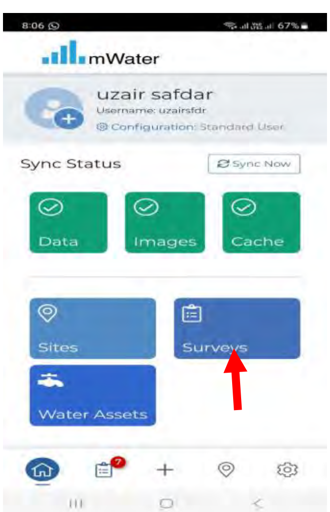
- Download from Play store with the name of (**mWater surveyor**)



- Made Log-In ID on App and use it for Portal on PC.

mWater App

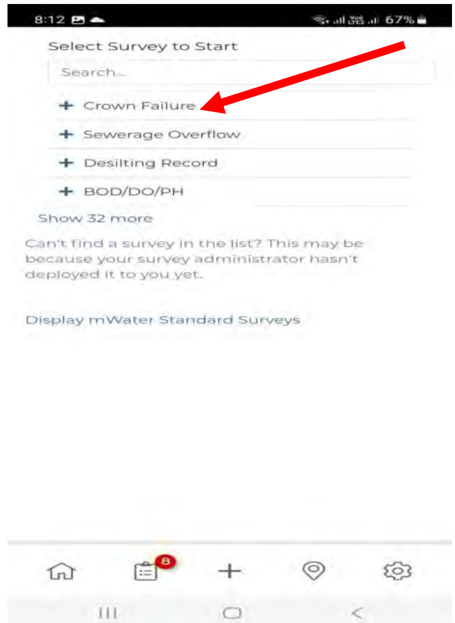
- After logging in, Click "Survey" icon



- Click icon "Start Survey"

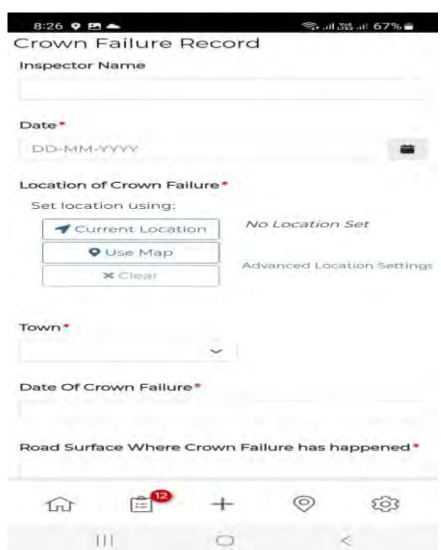
mWater App

- Select Survey Form



mWater App

Put the information related to the activity. e.g. Crown Failure repair work



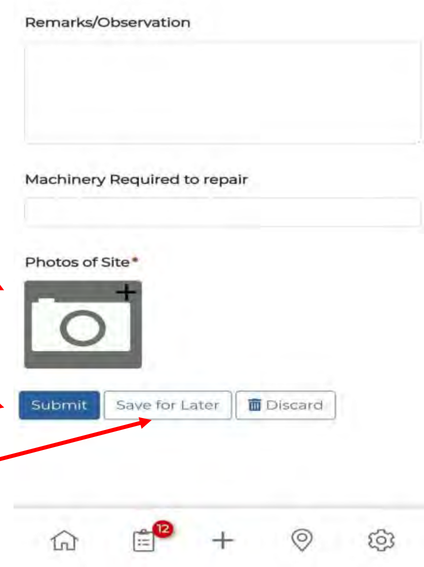
mWater app

- Take photo

  and

- Click “Submit”.

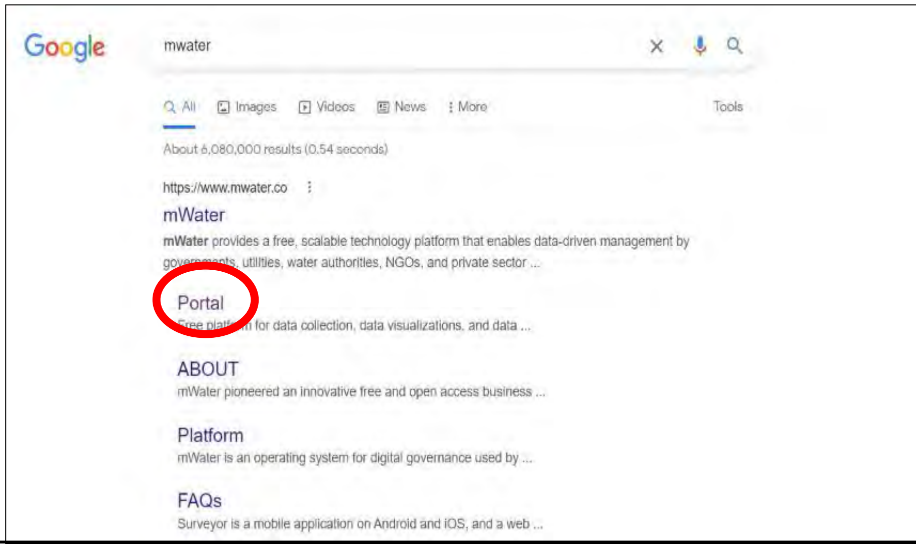
- When Internet is not available, Click “Save for Later”



mWater Portal

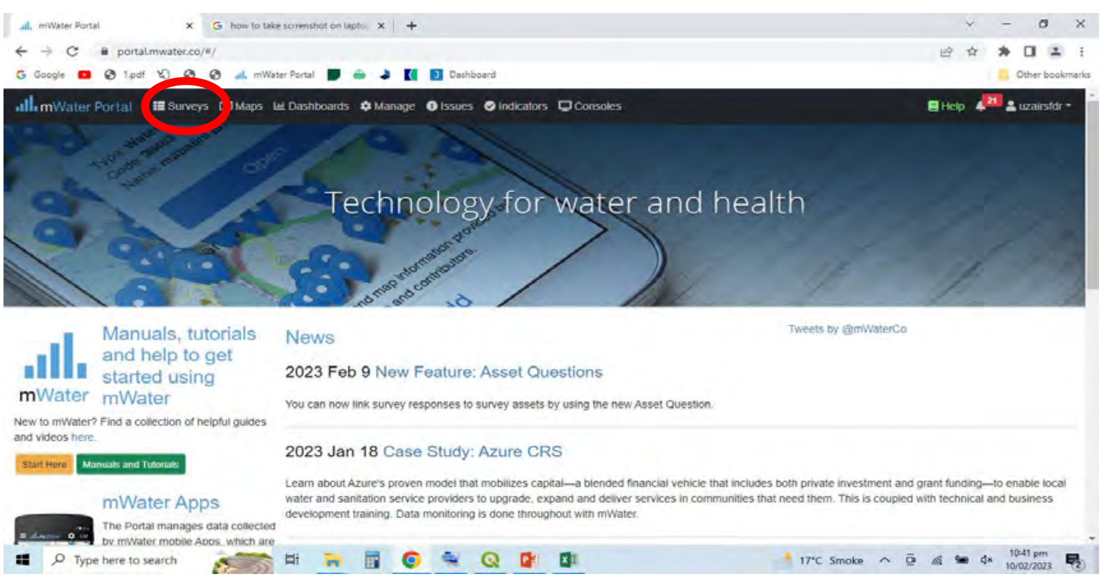
mWater Portal

- After the submission from mWater app, we can see the results on our PC or browser on smartphone or tablet, and analyze the results.



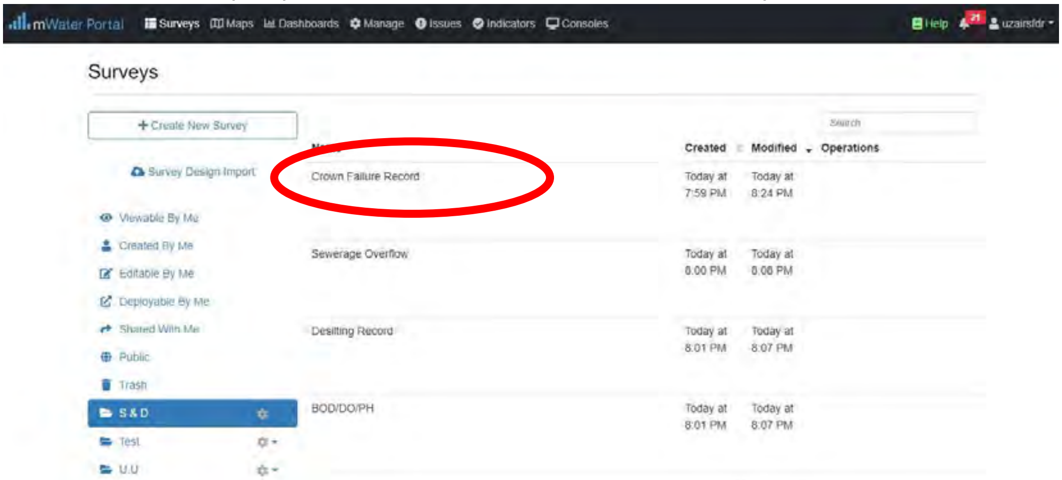
mWater Portal

- After Log in, click on “Survey” ICON.



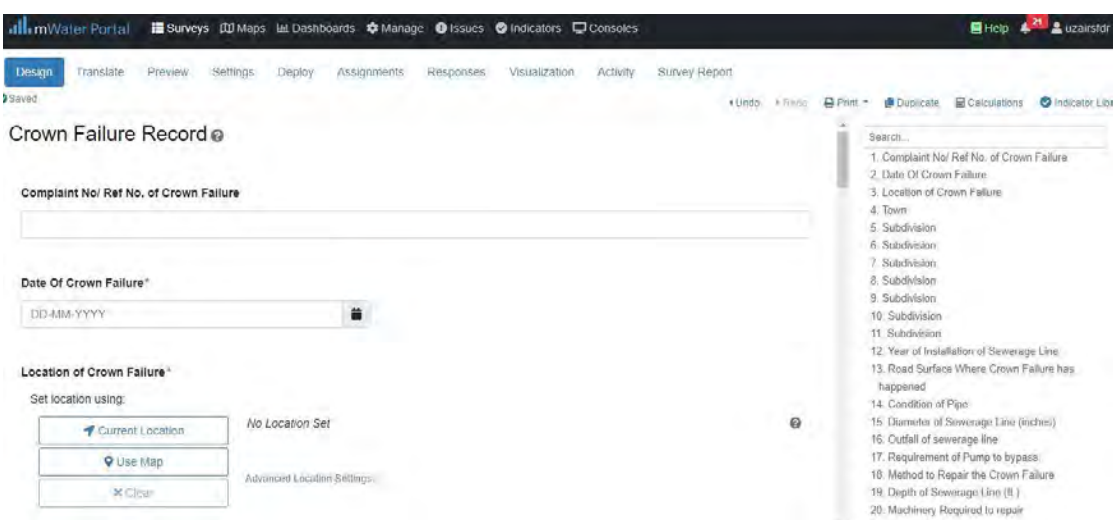
mWater Portal

- We can either use prepared form or create new survey



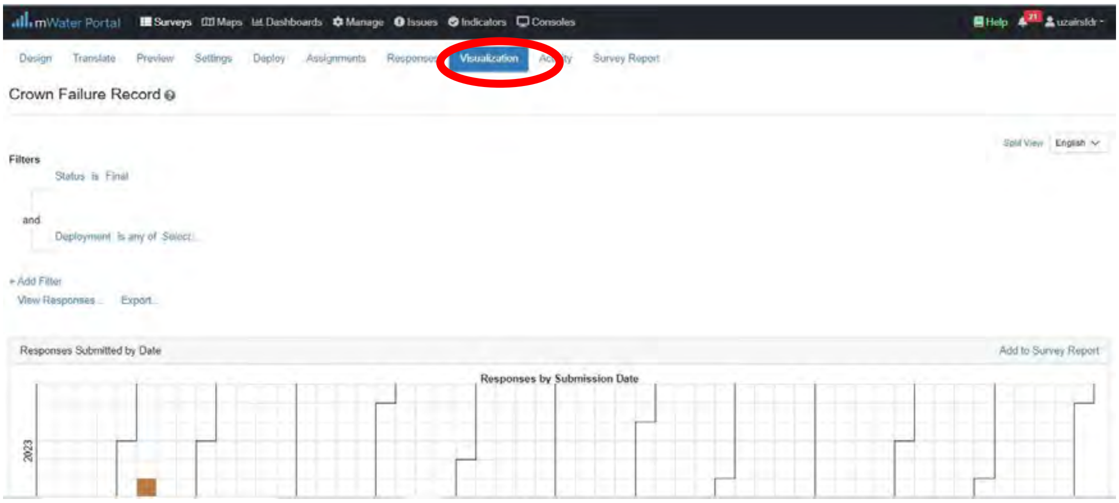
mWater Portal

- Click on Crown failure Record Form



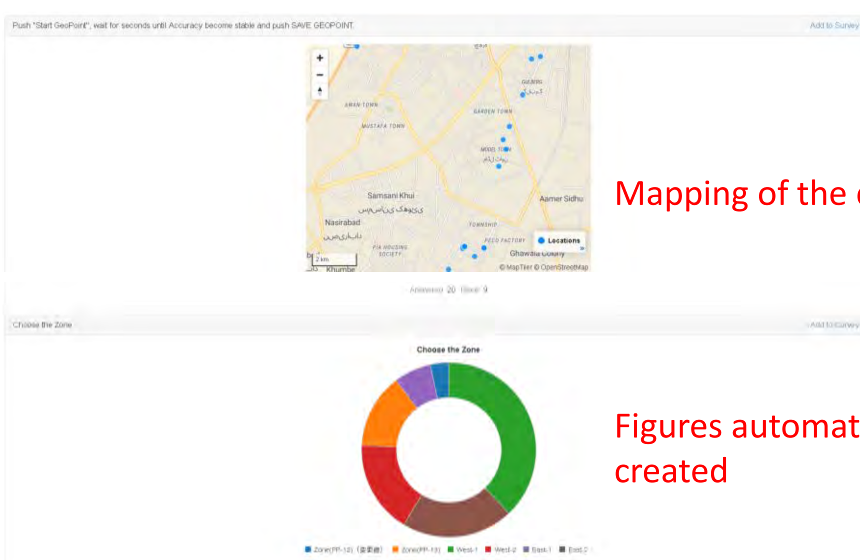
mWater Portal

- To see the form click on visualization



mWater Portal

- Example of Visualized data

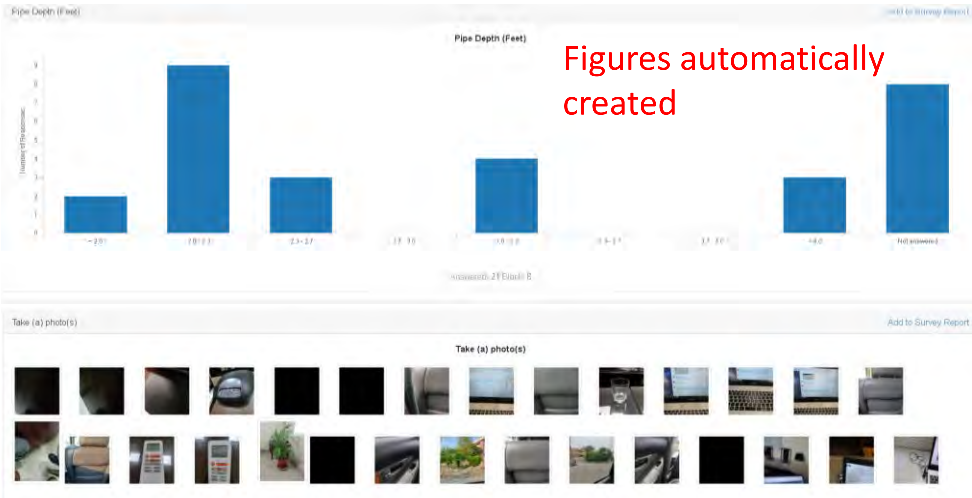


Mapping of the cases

Figures automatically created

mWater Portal

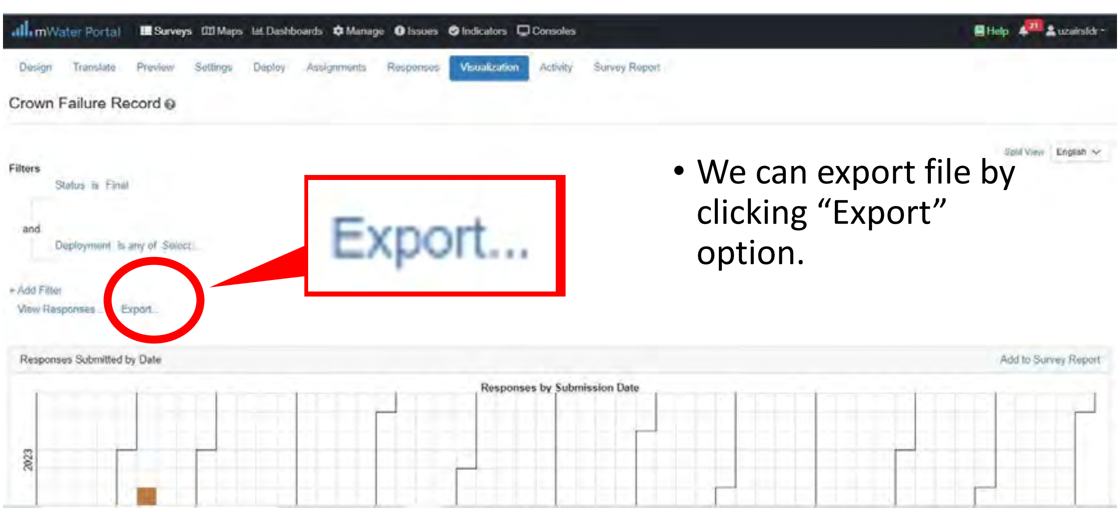
- Example of Visualized data



Figures automatically created

Photos

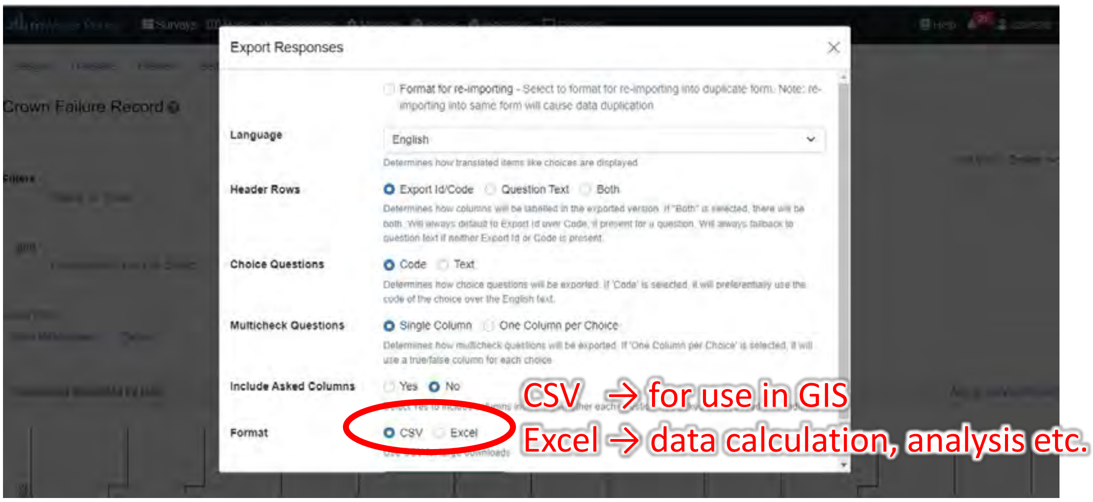
mWater Portal



- We can export file by clicking “Export” option.

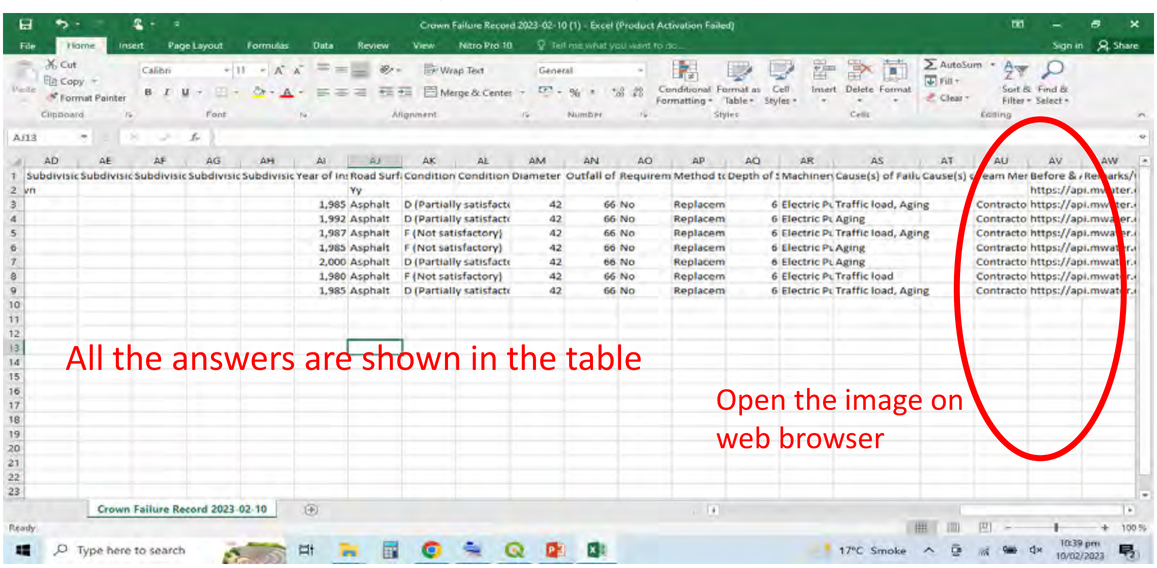
mWater Portal

Click on Export Option to export this file into Excel or CSV (used in QGIS)



Downloaded Excel sheet

(.xlsx or .csv)



QGIS

(PC Software)

QGIS Software

Index

- Use of QGIS software
- How to see mWater data and show them on **QGIS**.
- How to utilize the data

Step-1: How to install QGIS

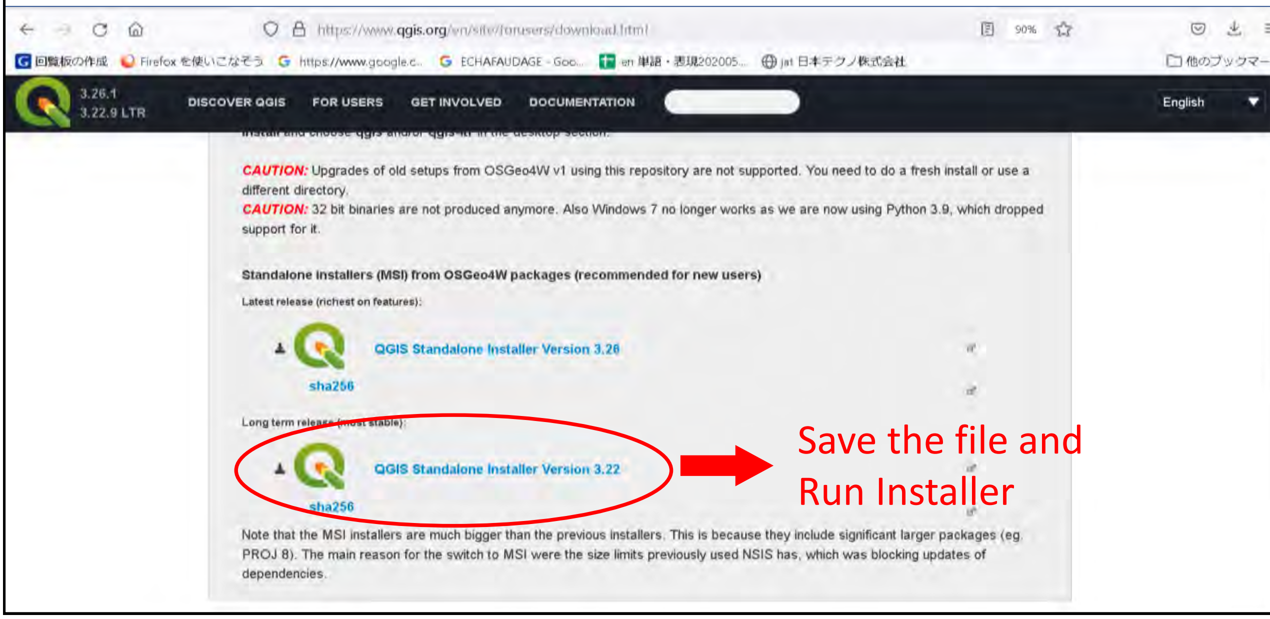
Geographic Information System GIS

A geographic information system (GIS) is a system that creates, manages, analyzes, and maps all types of data. GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what things are like there).

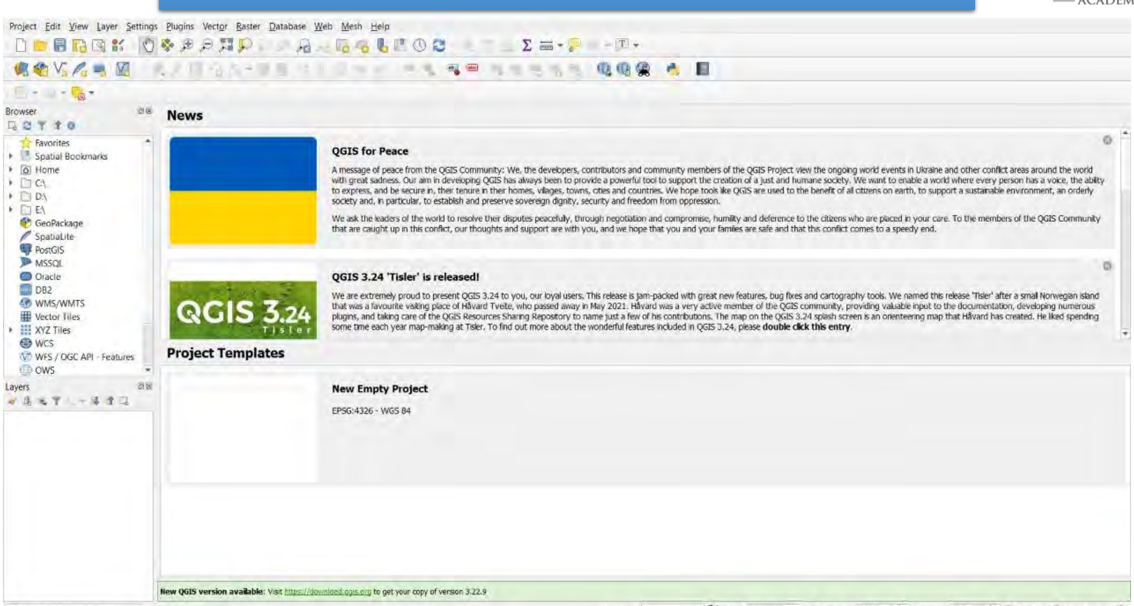
Types of Data Inputs in **GIS**

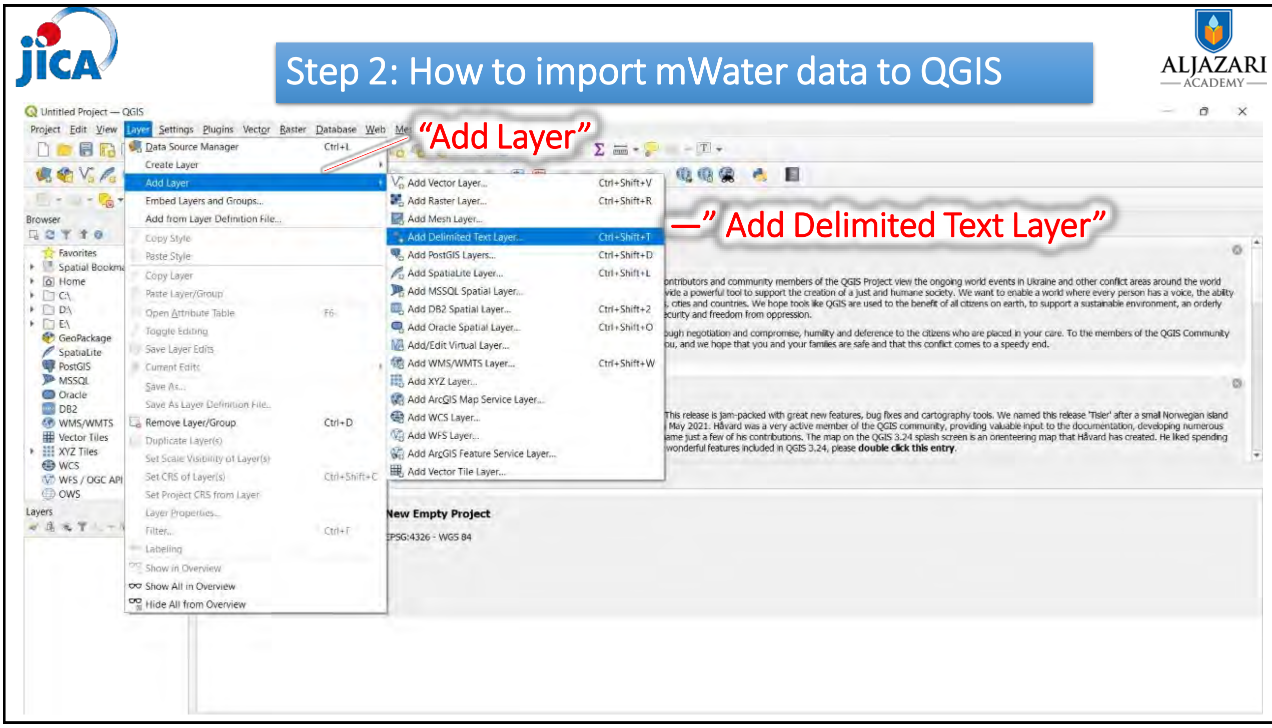
1. Vector Data
2. Raster data
3. Excel Data

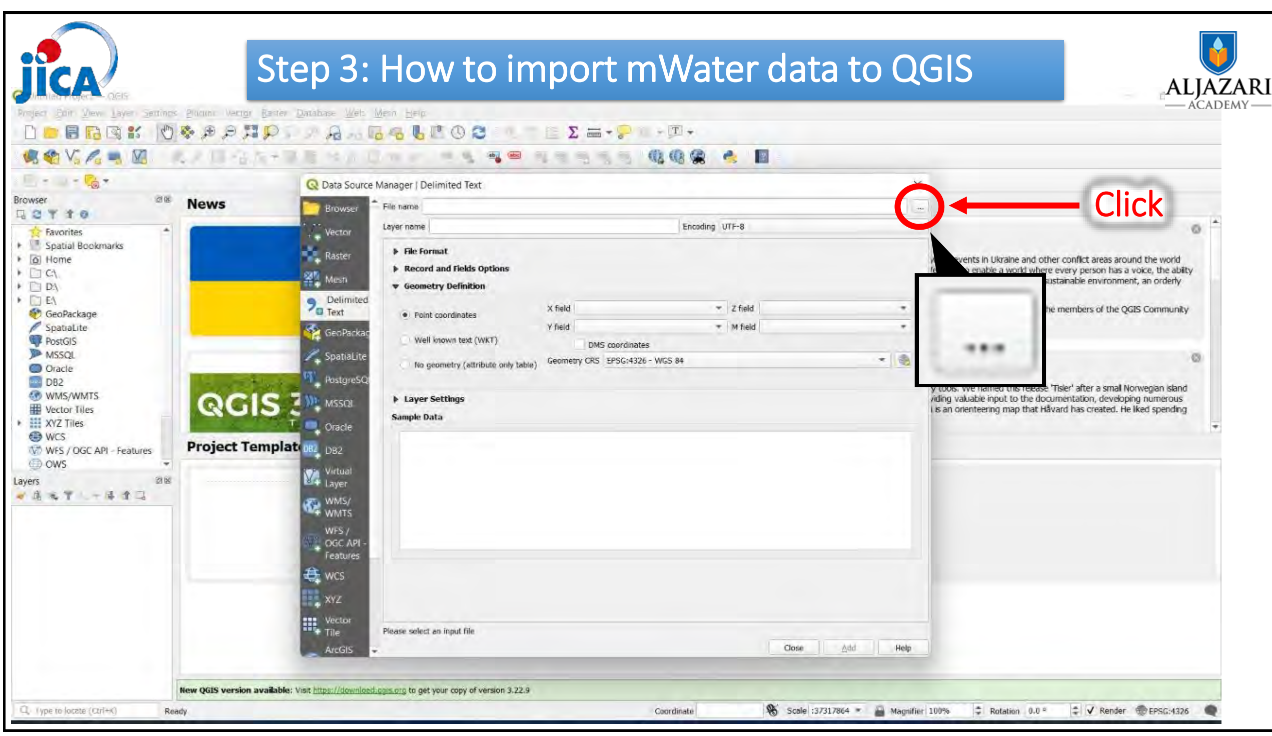
Step 2: How to install QGIS



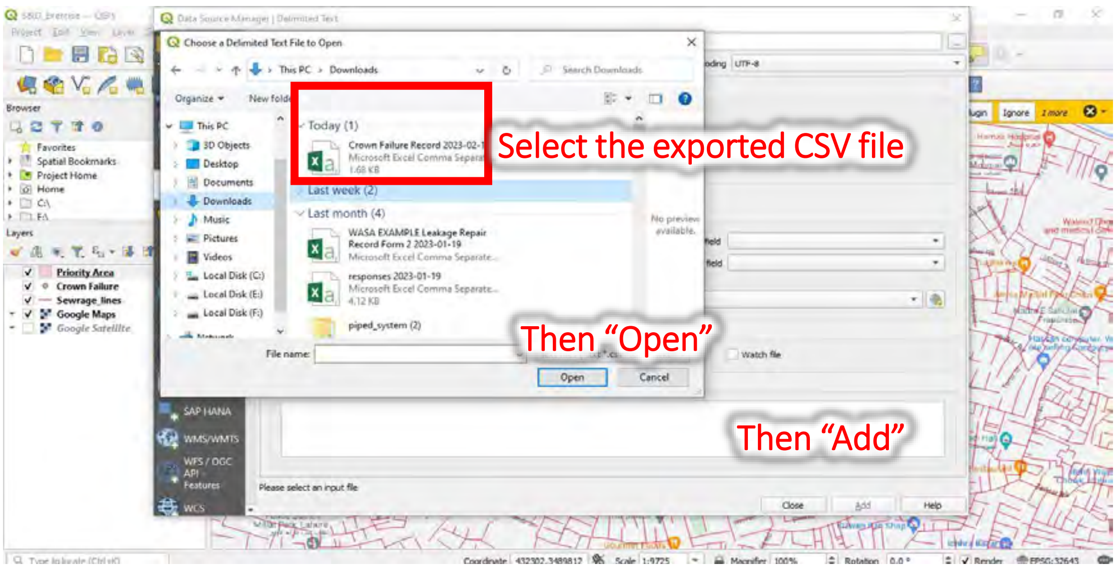
Step 1: How to import mWater data to QGIS




Step 2: How to import mWater data to QGIS
ALJAZARI
ACADEMY
"Add Layer"
—" Add Delimited Text Layer"

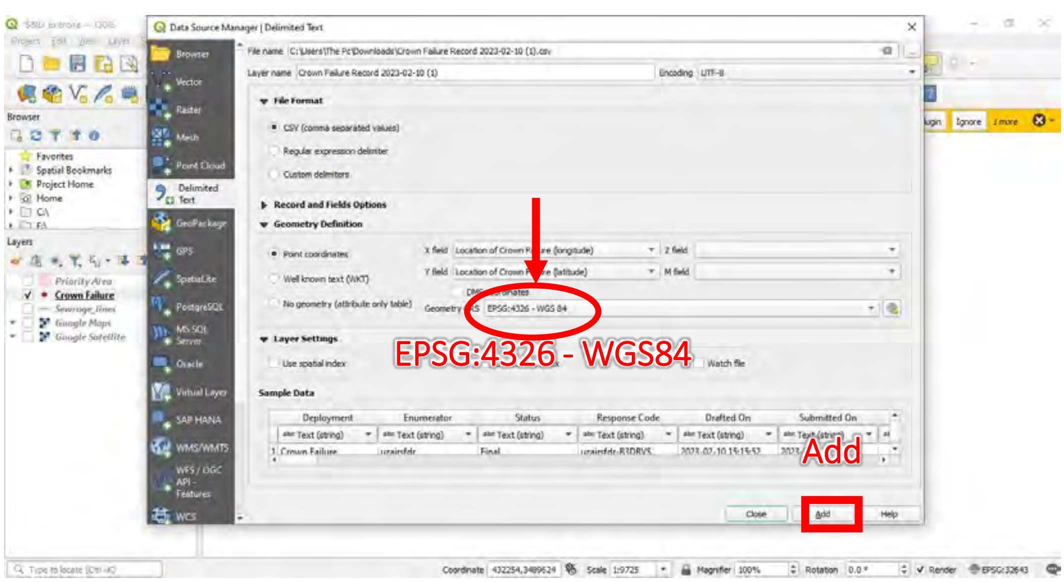

Step 3: How to import mWater data to QGIS
ALJAZARI
ACADEMY
Click

Step 4: How to import mWater data to QGIS



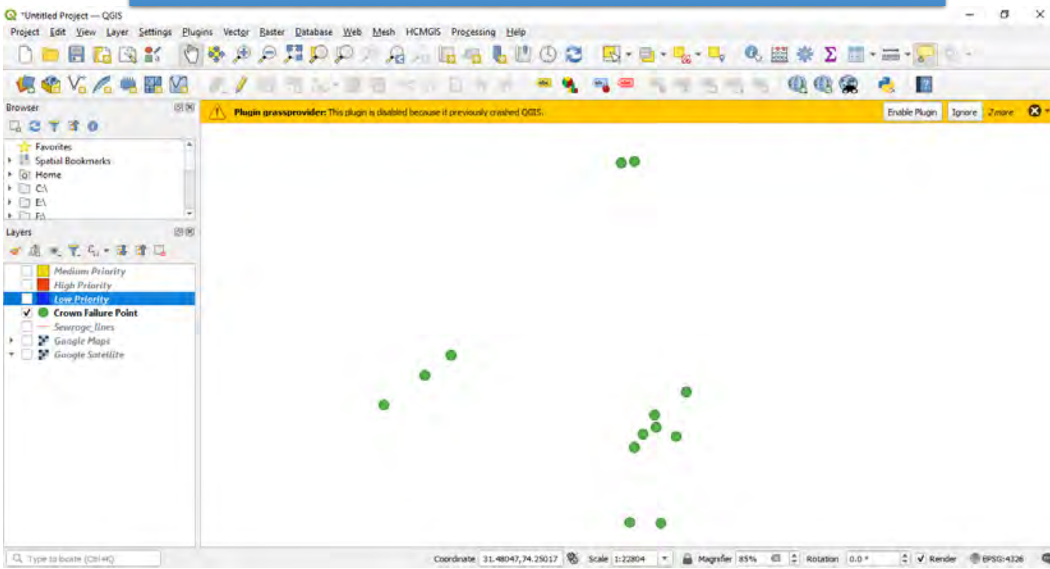
Step 5: How to import mWater data to QGIS

• .



Step 6: How to import mWater data to QGIS

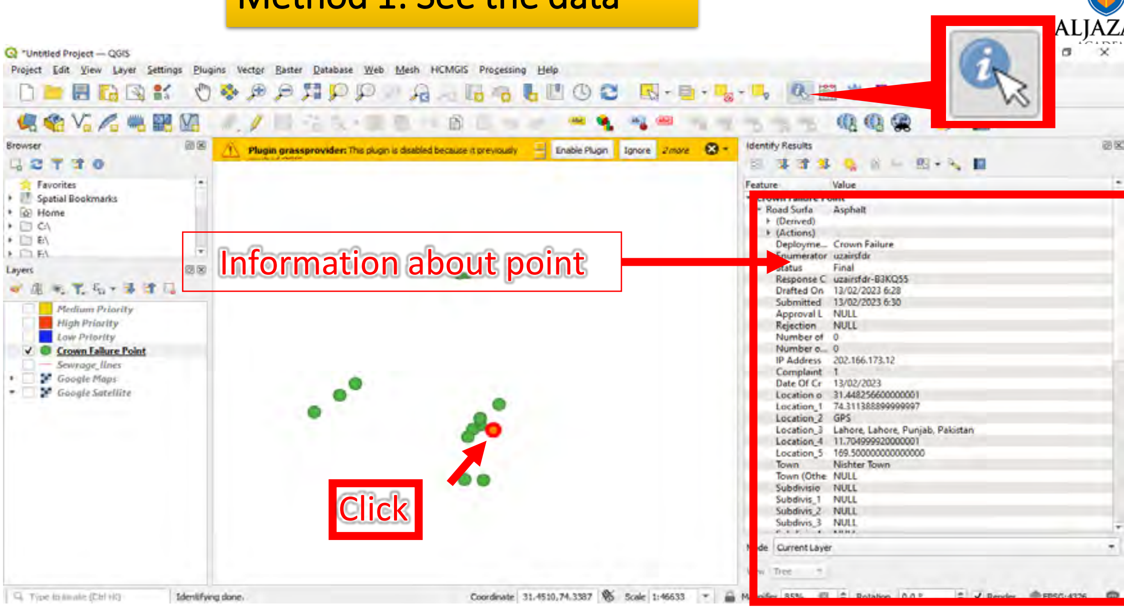
ALJAZARI
ACADEMY



Method 1: See the data

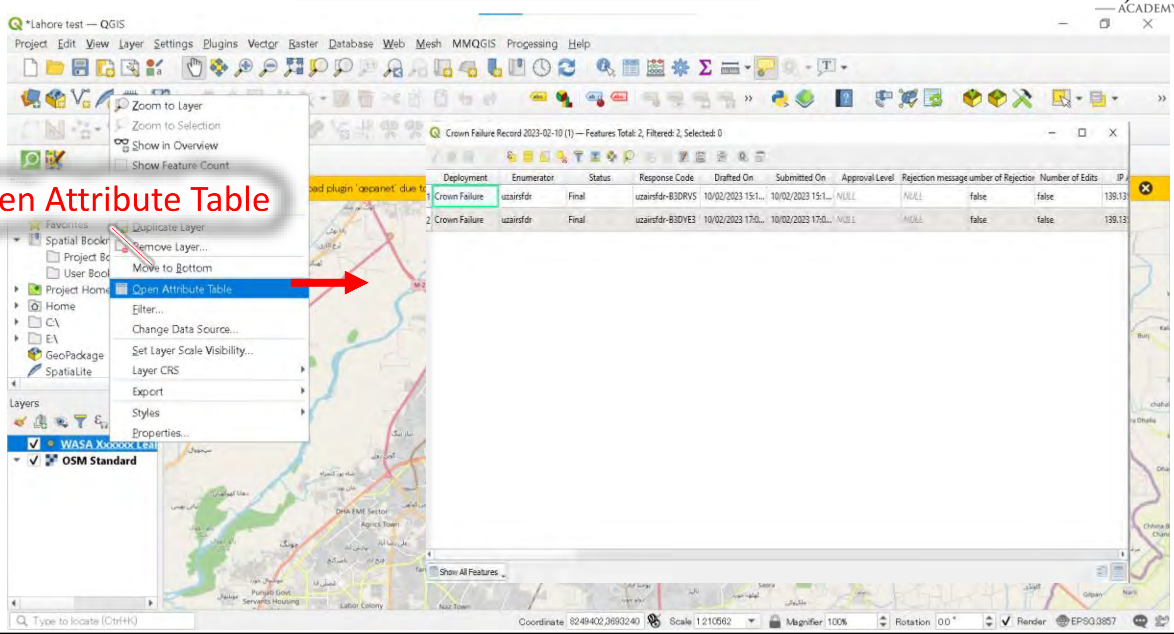
ALJAZARI

- .

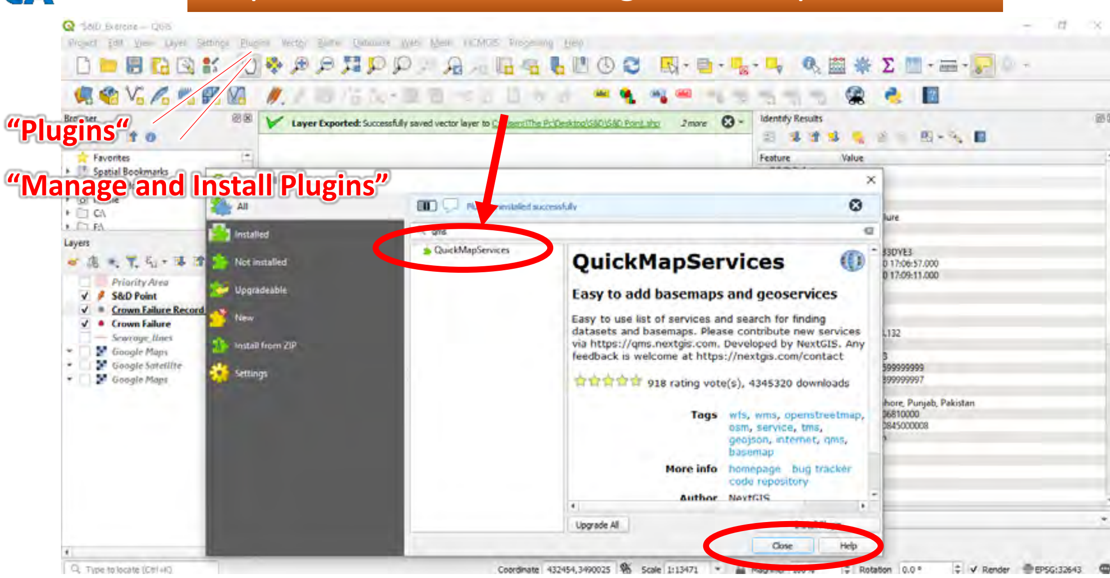


Method 2: See the data

- .

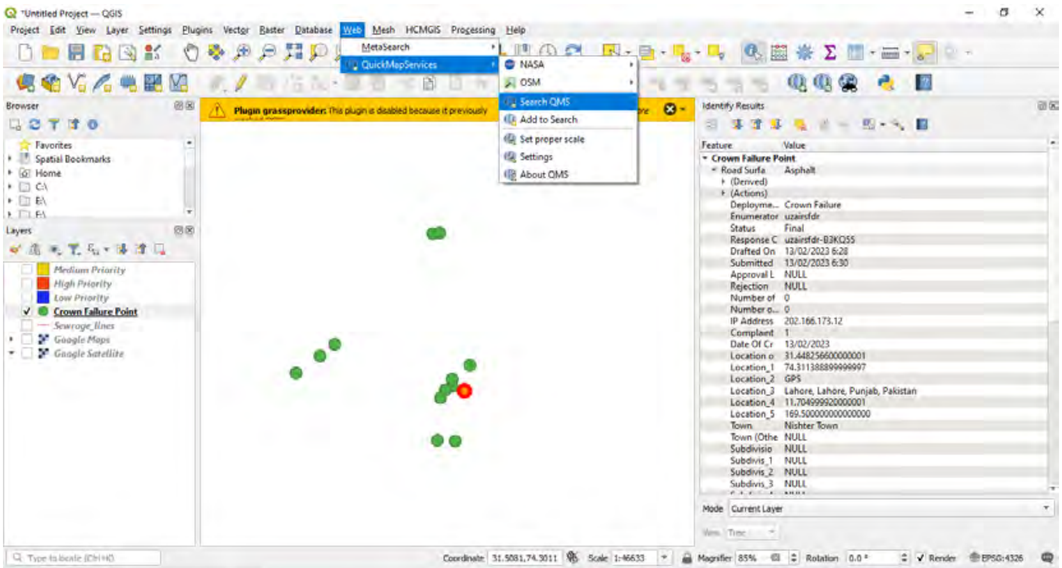


Step 1: How to show Background Map



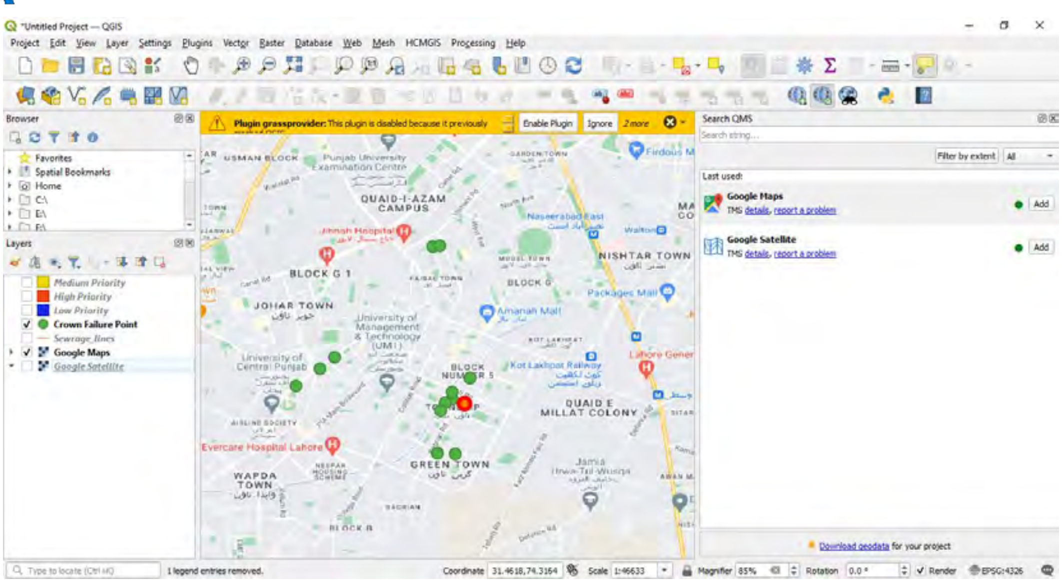
Step 2: How to show Background Map

ALJAZARI ACADEMY



Step 3: How to show Background Map

ALJAZARI ACADEMY



Lecture 4

Measurement of Sludge Quantity in Drains

Lecture Details

Class Work
Field Work

Documents
Equipment & Tools
PPE

- Presentation + Discussion on Current Practices
- Estimation of Deposited Sludge (at Maulana Shaukat Ali Drain, Akbar Chowk, Township)
- Drain map of area + Templates
- Ranging Rod + Aluminum Staff + Distance Meter+ Road Signs + Traffic Cones etc.
- Helmet + Goggles + Hand Gloves + Safety Shoes + Gum Boots







Ranging Rod

- Ranging Rod (6 feet Height)
- Colour Coded
- Each Segment is 01 Foot Long
- Metal Conical Tip for Penetration in Sludge

Distance Meter (Surveyor's Wheel) & Use

Step 01

Before Measurement (Reading 0-0)

Lo = 119 m

Step 02

Li = 115 m

Step 03

Sludge Measuring Procedure

1. First **select the venue** where you have to do dredging or sediment thickness measurement
2. Select some **culvert or bridge**
3. Properly apply **traffic control plan**
4. Ensure that each worker has worn the proper **safety gadgets**
5. Find out the **dimensions** of the drain i.e. Length Width and Depth
6. **Mark** the stations on the drain

Sludge Measuring Procedure

7. Two persons at both banks of the drain are required
8. **Find the depth** by using staff having graduations on it
9. Find out the **capacity of dump truck** for transporting sludge
10. **Calculate the number of trips** by dumper from dredging to disposal site
11. Also calculate the **time required by the dumper per tri**p and total time for overall operation
12. If the **cleaning along the road** is required because of spillage of waste then clean that

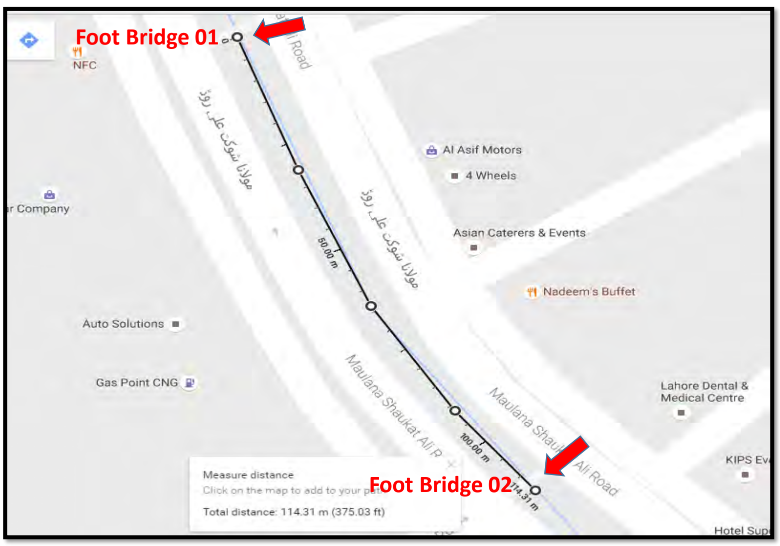
Road Map for Field Work

Road Map for Sludge Measurement Site

Maulana Shaukat Ali Road (Near Shauk Chowk)

Distance: 4.0 Km
Travel Time: 10 Min.

Layout Map of Drain Segment



Top View of Field Work Area (Sludge Measurement Site)

Maulana Shaukat Ali Road (Near Shauk Chowk)

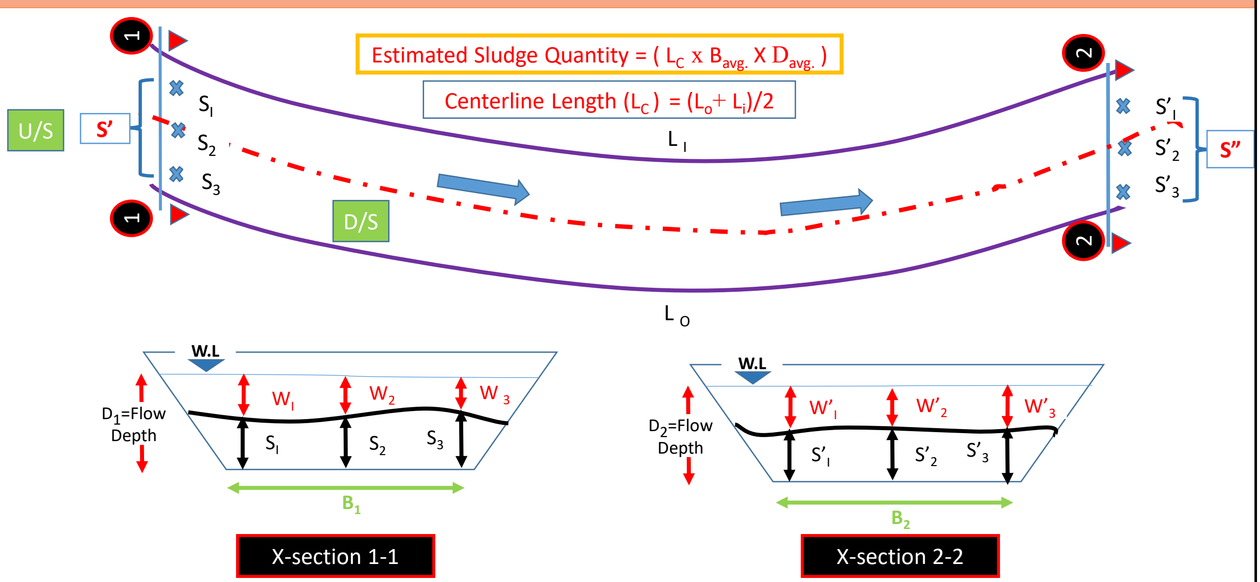
Foot Bridges

Foot Bridge 01

Foot Bridge 02

Maulana Shaukat Ali Drain (Secondary Type)

Sketches (Layout and X-Section)



Sludge Volume Calculation

Depth at Foot 1 S_n= (D- W_n)		Avg. Depth at Foot 1 S_{avg}	Depth at Foot 2 S_n= (D- W_n)		Avg. Depth at Foot 2 S'_{avg}	Overall Avg. Depth D_{avg}	Width at Foot 1 B_1	Width at Foot 2 B_2	Avg. Width B_{avg}	Length Inner L_i	Length Outer L_o	L_c	Sludge Volume V
S_1			S'_1										
S_2			S'_2										
S_3			S'_3										

D_1=

D_2=

Estimated Sludge Quantity (Vol.)
= (L_C X $B_{avg.}$ X $D_{avg.}$)
CUM or CFT

Estimated Sludge Quantity (Vol)
= (X X)
CUM or CFT

L_C = (L_O + L_I) / 2 (if drain stretch is curved)
S' = (S_1 +S_2 +S_3 + …) / n
S'' = (S'_1 +S'_2 +S'_3 + …) / n
$D_{avg.}$ = (S' + S'' + S'''+ …) / n
$B_{avg.}$ = (B_1 + B_2 + B_3 + …) / n

BOD: Biochemical Oxygen Demand Test

How to Use

1.

Pull out the line at the end of the tube

2.

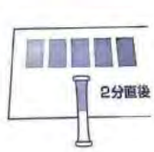
With the hole up, pinch the bottom half of the tube tightly with your finger and push out the air inside

BOD: Biochemical Oxygen Demand Test

3.

Continue to place the hole in the test water, loosen the pinching fingers, and wait until half of the water is absorbed. Shake the tube gently 15 times to prevent leakage.

4.

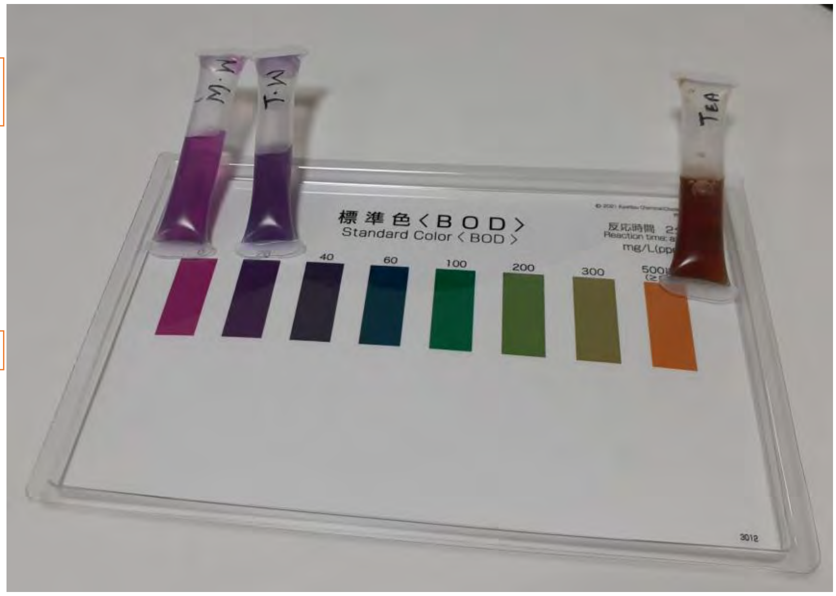


Immediately after 2 minutes, place the tube on top of the standard color and compare the colors.

BOD Test Results

Mineral Water (MW)

Tap Water (TP)



Tea

Quiz

Operation and Maintenance (O&M) of Sewerage System

Name of Trainee		Organization	
Total Marks	10	Obtained Marks	

Short Answer Questions

1. **What are the reasons for cleaning sewer & manhole?**

____

____

____

2. **Enlist various tools and equipment, required for sewer cleaning?**

____

____

____

Fill in the Blanks

1. Hydrogen sulfide (H_2S) may attack ________________manholes (Concrete/ Plastic)
2. Pole mounted sewer camera is used to find _________________ connection. (cable / illegal)
3. Preventive maintenance can save the _______________. (time & money / nothing)

True/False

Sr. No.	Statement	Yes	No
1.	First stage of inspection is CCTV?		
2.	The maximum range of pole mounted sewer camera is 20 feet?		
3.	Is it necessary to ventilate the manhole before its cleaning?		

ALJAZARI ACADEMY

SANITARY SEWER MANHOLE INSPECTION FORM		
M.H Depth: **From:**	**M.H #:**	**Date:**
I. Initial Inspection	**II. Structural Inspection**	**III. Hydraulic Inspection**
A. Location 1. Roadway ☐ 2. Gutter ☐ 3. Paved Alley ☐ 4. Unpaved Alley ☐ 5. Easement ☐ 6. Other ☐ **B.** Manhole Cover 1. Serviceable ☐ 2. Damaged ☐ 3. Displaced ☐ 4. Missing Grout ☐ 5. Needs Raising ☐ 6. Needs Lowering ☐ **C.** Ring & Frame 1. Serviceable ☐ 2. Damaged ☐ 3. Displaced ☐ 4. Missing Grout ☐ 5. Needs Raising ☐ 6. Needs Lowering ☐ **D.** Manhole Material 1. Brick ☐ 2. Concrete ☐ **E.** Size M.H Cover 1. 24 inch ☐ 2. 30 inch ☐ **F.** Manhole Size 1. 4 foot ☐ 2. 5 foot ☐	**A.** Steps 1. Serviceable ☐ 2. Unsafe ☐ 3. Missing (No.) ☐ 4. Corroded ☐ **B.** Cone 1. Serviceable ☐ 2. Broken ☐ 3. Leakage ☐ **C.** Riser 1. Serviceable ☐ 2. Broken ☐ 3. Leakage ☐ **D.** Shelf 1. Serviceable ☐ 2. Broken ☐ 3. Dirty ☐ 4. Bad Base Joint ☐ **E.** Channel 1. Serviceable ☐ 2. Obstructed ☐ 3. Bad Pipe Joint ☐ 4. Sit ☐ 5. Poor Structure ☐	**A.** Inflow Indication 1. Debris on Sides ☐ **B.** Surcharge Indicator 1. Greases / Debris on sides ☐ **C.** Clarity of Flow 1. Turbid Appearance ☐ 2. Clear Appearance ☐ **D.** Flow 1. Steady ☐ 2. Turbulent ☐ 3. Surcharging ☐ 4. Sluggish ☐ **E.** Flow Depth Compared to Adjacent Manhole 1. Same ☐ 2. Lower ☐ 3. Higher ☐ **IV. Vermin** 1. Roaches ☐ 2. Rats ☐ 3. Other ☐
Observation Summary:		