# UNIVERSITY OF BENIN

*Benin City, Nigeria*

*Training Course 4*

# OPERATION AND MAINTENANCE OF WATER DISTRIBUTION SYSTEM

Module 1: Introduction to Water Distribution System
Module 2: Elements of Water Distribution System
Module 3: Critical Appurtenances in Water Distribution System
Module 4: Maintenance of pipes, pumps and fitting of water distribution system
Module 5: Valves Maintenance, Fire Hydrants

**TRIANING COURSE 4: OPERATION AND MAINTENANCE OF WATER DISTRIBUTION SYSTEM**

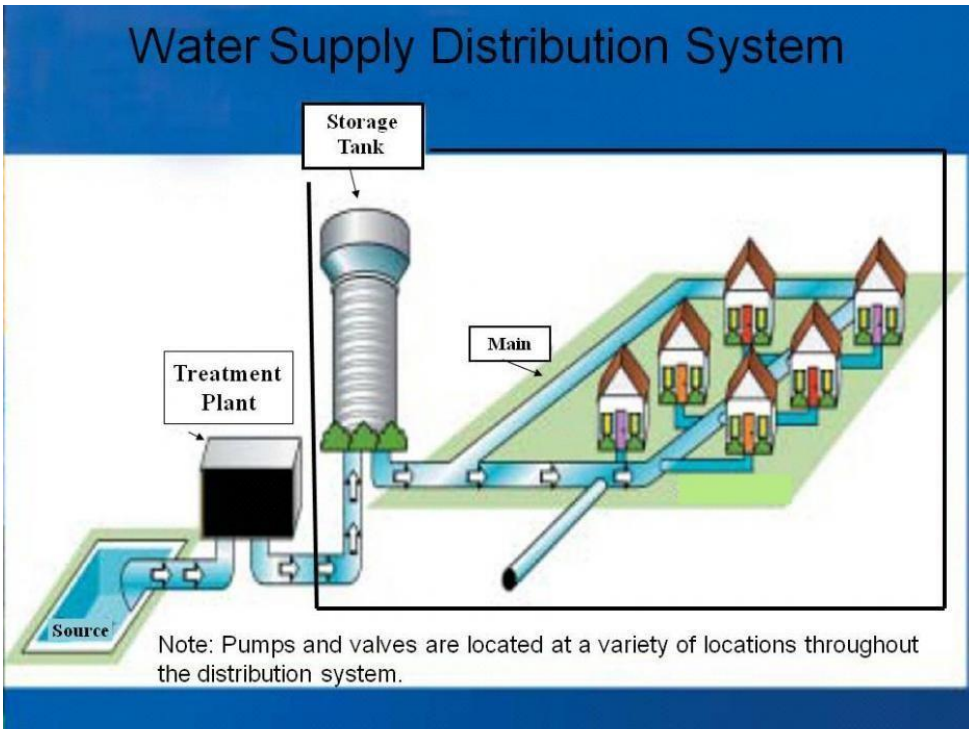
**Objective:**

Training low and medium level skilled personnel on the operation and maintenance of water distribution system

**MODULE 1: INTRODUCTION TO WATER DISTRIBUTION SYSTEM**

Water Distribution system is that part of water supply scheme that takes the treated water from the reservoir or the headwork through a system of pipe connections to the consumer. Prior to water distribution, there is water treatment and water transmission aspects.

Water utilities construct, operate, and maintain water supply systems. The basic function of these water utilities is to obtain water from a source, treat the water to an acceptable quality, and deliver the desired quantity of water to the appropriate place at the appropriate time. The analysis of a water utility is often devoted to the evaluation of one or more of the six major functional components of the utility: source development, raw water transmission, raw water storage, treatment, finished water storage, and finished water distributions well as associated subcomponents. Because of their interaction, finished water storage is usually evaluated in conjunction with finished water distribution and raw water storage is usually evaluated in conjunction with the source.




**1.2 TYPES OF DISTRIBUTION SYSTEM AND THEIR APPLICATION**

The layout of pipeline in a location usually follows the street network pattern of the area. However, in planning a city or district, having efficient distribution of water, power or gas utilities in mind, the layout is predominantly arranged in a definite pattern. These patterns form the geometry of the distribution system. The three common geometry of water distribution system are

i. Branched Network
ii. Gridiron network
iii. Ring and Radial network.

**A. Branched Distribution Network**

In the branch geometry of pipe lines for water distribution, the source (which may be a reservoir, tank or treatment plant) is located at one extreme of the network with a single pipe proceeding from it and carrying sufficient water to supply other arterial pipes. This usually occurs in the rural areas, or where the source is likely far from the place of consumption. A schematic layout of the pipeline is shown in figure 2.1.

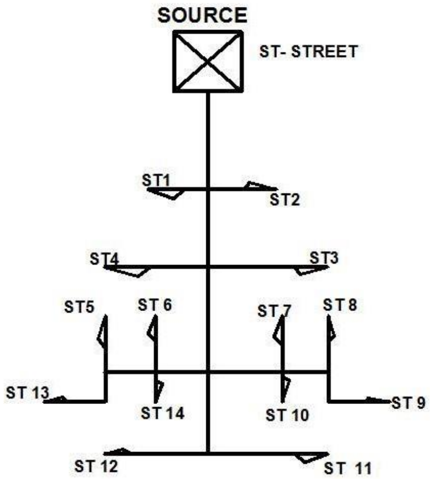



Figure 2.1: Branched distribution network Geometry.

**B. Gridiron Distribution Network**

In this geometry of pipeline, the all the streets are perpendicular to each other. This is recommended for urban centres where demand for water is high. The source is situated at the centre of the system with at least two pipes proceeding from the source. It is more efficient than the branched system in that a faulty in one pipe will not affect the total stoppage of water distribution in the network. It is however more expensive to build and maintain in actual practice. A layout of the gridiron pipe geometry is shown in figure 2.2.

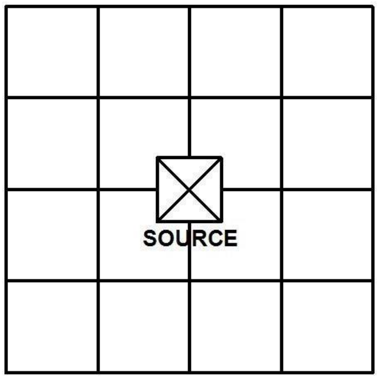



Figure 2.2: Gridiron Distribution Network Geometry.

**C. Ring and Radial Pipe Geometry**

These patterns of pipe arrangement occur where a circular arrangement of streets is proposed for development or in existence. It is similar in many respects to the gridiron as the source is situated in the middle of the distribution system. A minimum of two pipes is usually connected to the source as shown in figure 2.3. This pattern is aesthetically pleasing and can invoke tourism potential in the place of construction.

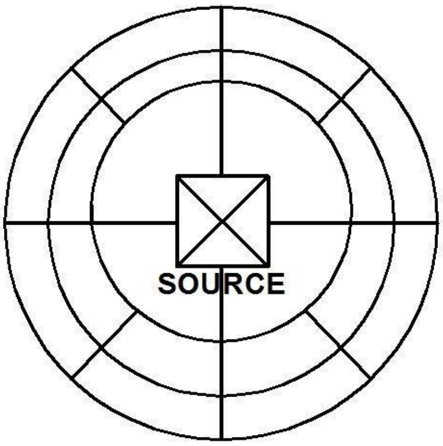



Figure 2.3: Ring and Radial Distribution Network Geometry

## 1.3 REQUIREMENT OF A GOOD DISTRIBUTION SYSTEM

i. Should be capable of supplying water at all the intended places within the city with a reasonably sufficient pressure head.

ii. It should be capable of supplying the requisite amount of water for fire fighting during such needs.

iii. It should be cheap with the least capital construction cost

iv. The economy and the cost of installing the distribution system should be cost effective.

v. It should be simple and easy to operate and repair thereby keeping the cost andother issue at the minimum.

vi. It should be safe against future pollution of water. This can be achieved by keepingthe water pipeline away from sewerage and drainage lines

vii. It should be safe as not to cause the failure of pipeline by bursting etc.

viii. It should be fairly water tight as to keep the losses due to leakage to the minimum

**MODULE 2.0 Elements of Water Distribution**

Urban water distribution is composed of three major components: distribution piping, distribution storage, and pumping stations. These components can be further divided into subcomponents, which can in turn be divided into sub-subcomponents. For example, the pumping station component consists of structural, electrical, piping, and pumping unit subcomponents. The pumping unit can be further divided into sub-subcomponents: pump, driver, controls, power transmission, and piping and valves. The exact definition of components, subcomponents, and sub-subcomponents is somewhat fluid and depends on the level of detail of the required analysis and, to a somewhat greater extent, the level of detail of available data. In fact, the concept component-subcomponent-subsubcomponent merely defines a hierarchy of building blocks used to construct the urban water distribution system.

- *Subsub-components.* Subsubcomponents represent the basic building blocks of systems. Individual sub-subcomponents may be common to a number of subcomponents within the water distribution system. Seven sub-subcomponents can be readily identified for analysis: pipes, valves, pumps, drivers, power transmission units, controls, and storage tanks.
- *Subcomponents.* Subcomponents representing the basic building blocks for components are composed of one or more sub-subcomponents integrated into a common operational element. For example, the pumping unit subcomponent is composed of pipes, valves, pump, driver, power transmission and control sub-subcomponents. Three subcomponents can be used to evaluate the reliability of the urban water distribution systems: pumping units, pipe links, and storage tanks.
- *Components:* Components represent the largest functional elements in an urban water distribution system. Components are composed of one or more subcomponents. These include distribution piping, distribution storage, and pumping stations. Distribution piping is either branched or looped, or is a combination of branched, and looped.

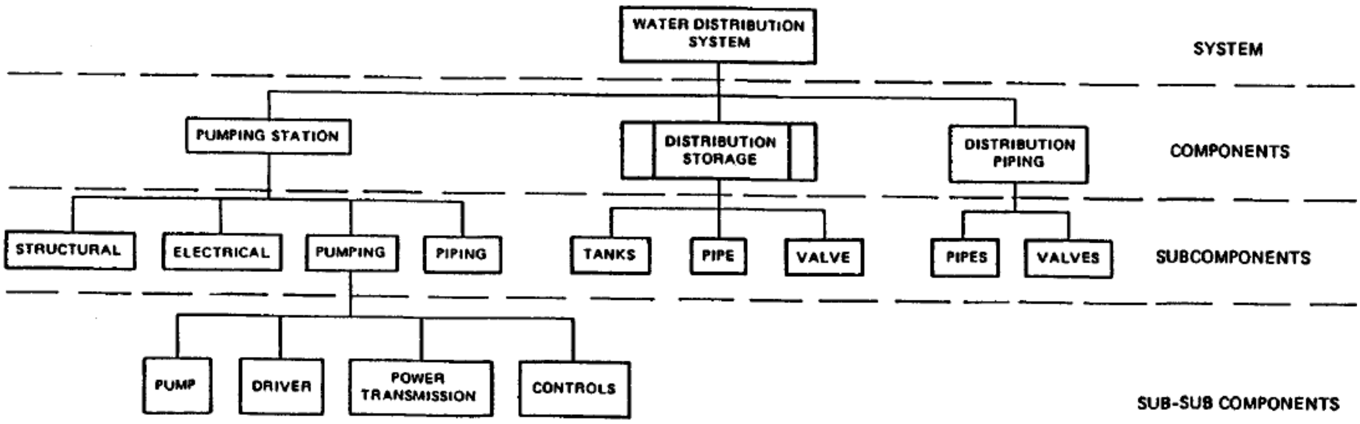



**Figure 1: Relationship between component and subcomponent of a distribution system**

## 2.1 Pipe systems and pipe materials

The manner of connection of pipes within the distribution defines its pipe system. This usually stems from the source of pressure or cause of head differential causing water to flow from one point to another. The pipe system conveys water through conduit powered by either pumps (pumping pipe system) or by gravity (gravity pipe system).

Pipe materials:

The following are the various materials which are used for pipes:

i. Asbestos cement pipe
ii. Cast iron pipe
iii. Cement concrete pipe
iv. Copper pipes
v. Galvanised iron pipes
vi. Lead pipe
vii. Plastic pipe
viii. Steel pipe
ix. Wood pipe
x. Wrought iron

## 2.2 Operation of Water Distribution System

The operation of water distribution system can be divided into 3 operations: hydraulic operations, water quality operation and emergency operation.

### 2.2.1 Hydraulic operation

This has to do with defining the right speed and head of flow of water in this distribution system to avoid sudden burst of pipes. For systems whose operations are based on pressure, operators typically operate pumps and possibly valves so that system wide pressures are maintained within acceptable limits. Although what is considered to be acceptable may vary from system to system, pressures in most cases should be kept above 207 kPa (30 psi) and below 689 kPa (100 psi) during normal operations. Pressures much greater than 689 kpa (100 psi) tend to waste water through leaks and could damage residential and commercial plumbing systems or possibly cause main breaks. A pressure of 207 kPa (30 psi) allows water to be supplied to the top floors of a multi-storey building. Depending on the nature of the water supply system, minimum pressures greater than 207 kPa (30 psi) may have to be maintained at certain locations within the system. If the water system sells bulk amounts of water to an adjacent community, that community may require the water to be supplied at a minimum pressure of 345 kPa (50 psi) or higher. Operators must consider such unique circumstances in their operating decisions. Flow also can be used as a parameter to control a water distribution system. Many systems measure flow at pumping stations and at interconnections with other systems. What constitutes an acceptable range of flows generally is be dictated by the nature of the water distribution system. For example, if the purpose of the system is to sell bulk amounts of water to neighbouring communities, operators need to ensure that sufficient volumes of water are delivered to the system's customers. In addition, the water may have to be delivered at or higher than a specified pressure. Flow and pressure are directly related to one another. When the flows in a pipeline increase, the pressure at the end of the line will decrease. Therefore, although some operators may operate the system according to pressure, one also can think of those operators as operating the system according to flow. In other words, when the pressure in part of the system falls below acceptable limits, it does so because the usage in that part of the system is most likely to be high. Consequently, flows and pressures into that part of the system must be increased by placing a pump into service. Operators also can control valves to direct water to areas where it is needed, but this usually is not done in municipal water distribution systems. Among the more important parameters that an operator monitors is perhaps the water level in system tanks. Tank levels can provide an indication of the overall pressure throughout a pressure zone or even the entire system. Generally speaking, the higher the tank level, the higher the system pressure. In fact, operations in many systems are based solely on tank levels. For example, over time an operator may have developed an intrinsic feel for system wide pressures as a function of the level in one or more storage facilities. Operators must ensure that sufficient volumes of water are stored in tanks at all times in the event of an emergency, such as a fire, power failure or source outage. In fact, common operating practice in the recent past (and possibly even today in some systems) was to keep storage tanks as full as possible at all times.

### 2.2.2 Water Quality Operations

In recent times, much attention has been placed on the need for good water quality in distribution systems. This increased awareness has been driven in part by new federal regulations mandating that water-quality standards must be met at the customer's designations. Operations provide a great opportunity to affect water quality in existing distribution systems. For example, through their actions, operators can directly influence tank water levels and pumping operations. Through these actions, they may be able to bring fresh water from a treatment plant and direct it toward a certain part of the service area. Operators generally do not operate valves within the system to direct water to specific parts of the system. However, in the future such an approach may offer more control than traditional means of operating water distribution systems. In the near future, more water supply systems may consider using in-line booster disinfection stations or possibly even mini in-line treatment plants in an effort to improve overall water quality in the system. Because these elements are located within the distribution system, their operation will become the system operator's domain. Chemical feed rates would be monitored and controlled by the operator to maximize water quality.

### 2.2.3 Emergency Operations

The real reason human operators are used in larger systems is to respond to such emergencies as fires, main breaks, source contamination, source outage, or power failures. Operators must be able to respond to any emergency that arises and ensure that system performance remains at an acceptable level of service. During fires, operators may place more pumps into service to deliver higher rates of flow out into the system. During a power failure one of the operator's tasks may be to place a diesel or natural gas generator into service so that pumps can continue to operate. For many systems, however, backup generators automatically enter into service when a power failure occurs. During contamination of a source, the operator may have to close valves to isolate part of the system. Needless to say, emergency operations are an extremely important component of the operator's duties.

## MODULE 3.0 Critical Appurtenances in Water Distribution System

The critical appurtenances under consideration are valves, fire hydrants and the water meter.

### 3.1 Valve

Valve is a device that regulates controls or directs the flow of a fluid by opening, closing, or partially obstructing fluid flow. It is a mechanical device that controls the flow and pressure of fluid within a system or Process. So basically, it controls flow & pressure. Some of the examples of valves include

1) Gate Valve
2) Globe Valve
3) Check Valve
4) Plug valve
5) Ball Valve
6) Butterfly Valve
7) Needle Valve
8) Pinch Valve
9) Pressure Relief Valve

### 3.2 Fire hydrant

A fire hydrant is a visible fixture placed inside or outside a building, parking area, industrial area, mine, roadside, etc. that is connected to the municipal or a private water service network. Fire hydrants are designed to provide the water required by fire fighters to extinguish a fire. Two types of hydrants may be distinguished in a water distribution network, they are Post hydrant which projects about one metre above the street surface and Flush hydrant which is level with the surface of the street.

In most cases, a fire hydrant is the primary method of fire fighting in a municipal area. It is basically an outlet with a valve that provides water to the fire pumps or fire trucks engaged in fire fighting. Regulations for keeping operational fire hydrants at specific intervals and with free access in buildings, factories, urban and developed areas are an important component of fire control and safety.

**Fire hydrant**

### 3.3 Water Meter

A water meter is a device used to measure the flow of water through an outlet. It is usually employed for stipulating water charges and enabling cost recovery.

**Water meter used for costing**

### 3.4 Pumps

A pump is a machine that is used to lift water to a high elevation in a distribution system. Pumps are also employed to lift water from the aquifer system or surface water reservoir to elevation tanks. Pumps and turbine constitute the two hydraulic machines that considerably impart and extract energy from fluid in motion. While those in which work is done on the fluid are known as pumps, those that extracts energy from the fluid are called turbines. The process of energy transfer can be achieved by either positive displacement or rotodynamic action. In the first case, a volume of fluid fixed by dimensions of the machine enters and leaves it at a frequency determined by the speed of operation of the machine. In the second case, the flow is continuous through an impeller whose torque is equal to the rate of change of angular momentum of the fluid.

### 3.4.1 Types of Pumps

There are several of classifying pumps depending on their functions, names of inventor among others. For this discussion, pump will be classified into:

1. Roto-dynamic pump
2. Positive Displacement pump.

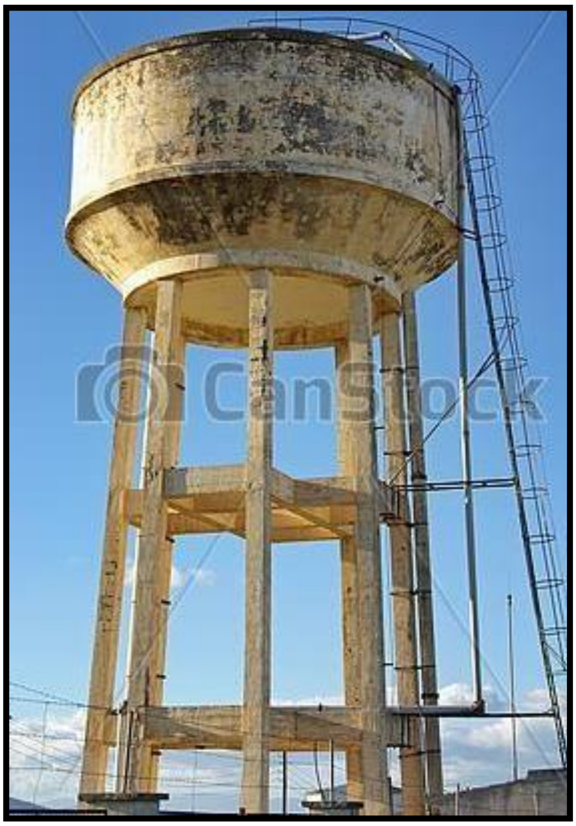
**Rotodynamic Pump**

**Positive Displacement Pump**

## 3.5 Storage Reservoir

The storage reservoir comprises the compartments for storing the water. Storage reservoir made of steel and concrete are popular in water distribution systems. They may also be classified into elevated reservoir and ground reservoir

Steel Elevated Tank




Concrete Elevated Tank


**MODULE 4.0 MAINTENANCE OF PIPES, PUMPS AND FITTINGS OF WATER DISTRIBUTION SYSTEM**

**4.1 Pipes**

The maintenance procedures of a pipe are outlined below:

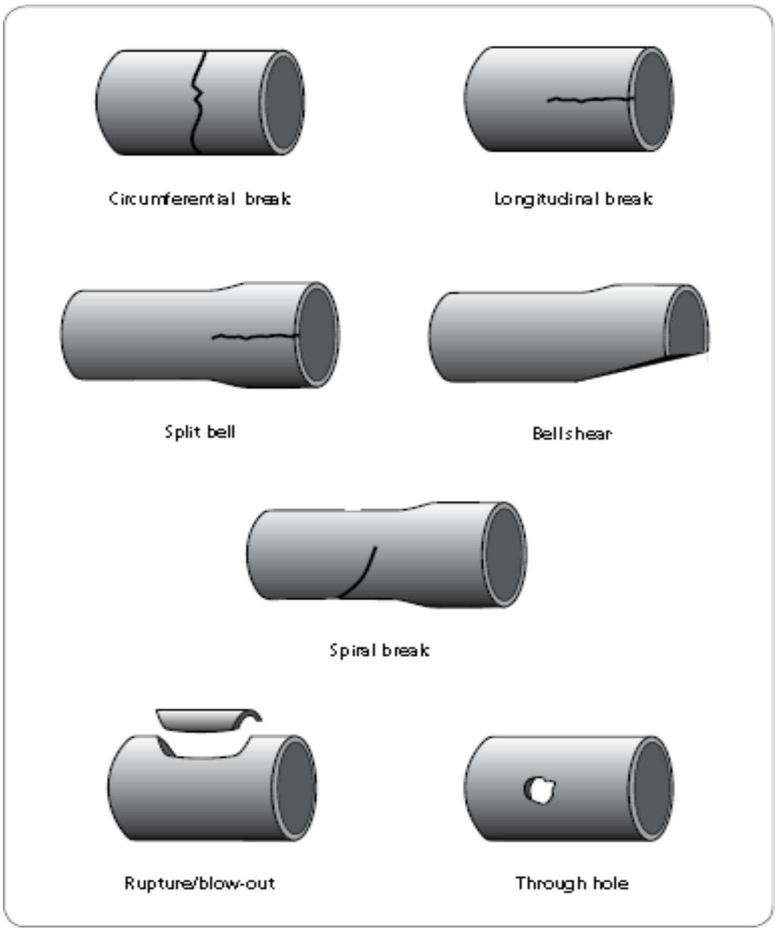



**Figure 1: Structural failure mode of water pipe**

***Check for pipe leaks*** through appropriate active leak detection methods at regular intervals.

***Flush pipes*** to remove accumulated sediments, especially those pipes where low velocities are likely to occur such as dead-end pipes.

A **rule of thumb** of **three failures** in the life of a pipe section is sometimes used as an indication that this point has been reached and the pipe should be replaced.


## 4.2 COMMON OPERATION AND MAINTENANCE TASK

### Locating pipes

Changes in pipe direction, including bends and T-junctions, should be marked with pipe markers so that it is possible to effectively locate a pipe for maintenance or expansion purposes. Valve boxes and hydrants may also be useful markers for the location of a pipe. In addition, as-built drawings should accurately indicate the location of pipes and other components. Where the above methods are not available, pipe location techniques may be useful to avoid unnecessary digging. The following techniques are available:

• Steel pipes may be located using electromagnetic ***metal detectors***, sometimes inducing a signal into the pipe from a valve or hydrant that may be picked up by an above-ground sensor.

• ***Other methods*** include ground-penetrating radar, sonic wave methods and infrared thermography.

• ***Excavating*** across the line of the pipe is a technique that may be used if other techniques are not available or fails. Care should be taken not to cause damage to the pipe with a pick or shovel during the digging process. It is a good idea to get different suppliers to demonstrate their equipment on a known section of pipe to ascertain their effectiveness before deciding on a system to purchase.

### 4.3 Locating leaks in Pipes

Various techniques exist for finding leaks through active detection. Some methods are better suited to certain pipe materials and diameters, and whether the pipe has service connections on it or not. The main techniques are briefly explained below, and recommendations for methods to use are given in Table 15 and Table 16 i:

• ***A. Gas injection.*** In this method a gas detector is used to find the presence of a tracer gas that has been injected into an emptied pipe. Hydrogen is the most common gas employed, but helium can also be used. A probe is used along the route of the pipeline to detect gas released through leaks in the pipe.

• ***B. Manual listening stick.*** A stethoscope or listening stick with an earpiece is pressed against fittings to listen for nearby leaks in the pipe.

• **C: *Leak noise correlation.*** Leak noise correlators work by comparing the noise detected at two different points on the pipeline. The times that a noise signal reaches the respective sensors are used to estimate the location of the leak on a pipe. Noise correlators will also pick up non-leak sources of noise, and thus the existence of a leak should be verified, for instance using a ground microphone. Two types of noise correlators are used:

° ***D: Accelerometers.*** In this method, two accelerometer sensors are deployed on pipe fittings on either
side of the suspected leak position. This method is most effective on metallic pipes.

° ***E: Hydrophones.*** Leak location with accelerometers is harder in plastic pipes due to their higher elasticity,
and in large diameter pipes due to the higher diameter to wall thickness ratios. Hydrophones are placed in
contact with the water, for instance at hydrants, and pick up the noise signal directly from the water.

• ***F: In-line detection techniques.***

These techniques are suitable for large diameter pipelines. Probes are placed in the pipe and pick up leak noises as they pass through it. Tethered and free swimming systems are available.

• ***G: Leak noise loggers*** are placed on fittings and pick up the noise created by a leak in the pipe.

### 4.4 Repairing leaking pipes

The following steps are used to repair a leaking pipe:

1. ***Locate the failure*** from an external sign such as a water jet or wet area of soil, or from specialized leak detection equipment.
2. ***Close isolation valves*** in the system to isolate the leak. Clearly mark each valve that is closed, for instance on a worksheet or with a physical marker such as danger tape on the valve itself.
3. Ensure that the ***work area is safe*** for working using appropriate signs, barriers and traffic diversion measures.
4. ***Excavate*** the failed pipe section while ensuring worker safety and avoiding further damage to the pipe.
5. Use an extractor pump capable of handling sludge to ***drain water*** from the trench.
6. ***Repair*** the failed pipe using an appropriate method:

a. For a small leak, a ***repair clamp*** may be fixed over the leak to seal it. Small leaks in steel pipe may be welded closed.

b. For a more extensive leak, the ***damaged section of pipe is cut out***, a new section of pipe installed using appropriate connectors. PVC is often used for the replacement section and special fittings are available to connect PVC to other pipe materials. Note that AC pipes should not be cut – rather replace a whole length of pipe.

c. ***Replace a whole length*** of pipe if damage is extensive or it is clear that the pipe is bad condition and likely to fail again.

7. In all cases, ensure that exposed and new sections of pipe are ***carefully cleaned and disinfected***. Take special care to ensure that any solids that may have entered the pipe during the repair are removed.
8. Slowly open one or more of the closed isolation valves as well as a hydrant or valve to ***allow air to escape*** from the system.
9. Ensure that all isolation and scour valves opened or closed are reinstated to their correct state.
10. ***Flush*** the section using a hydrant to ensure that any contaminants and solids are removed.
11. Once the section is under pressure, ***inspect the repairs for leaks***.
12. Reinstate the pipe ***bedding, blanket and backfill*** using appropriate placing and compaction methods and materials.

13. ***Reinstate and clean*** the area where the excavations were done.

**Table 1: Recommended leak detection techniques on pipe without service connection**

| Pipe material | Small diameters (75 – 400 mm) | Large diameter pipes (from 300mm) |
|---|---|---|
| Metals | A, B, C, D, F, G | C, D, E |
| AC | A, C, D | E |
| PVC | A, D | E |
| Polyethylene | A, D | E |

**Table 2: Recommended leak detection techniques on pipe with service connection**

| Pipe material | Small diameters (75 – 400 mm) | Large diameter pipes (from 300mm) |
|---|---|---|
| Metals | A, B, C, D, F, G | C, D, E |
| AC | A, C, D, F G | E |
| PVC | A, D, F G | E |
| Polyethylene | A, D, F G | E |

### 4.5 Pumps

Health and safety requirements are very important in pump stations, including not wearing loose clothing, preventing accidental contact with moving equipment, switching off electricity when working on electrical equipment, ear protection and ensuring that pumps are completely switched off (and cannot be switched on automatically) when working on them. Backup power supply should be tested regularly to ensure that it is in good operating condition and starts up automatically. Backup engines should be run for at least one hour a month to lubricate all internal parts and ensure that batteries are fully charged. Switchgear on engines and generators should be checked regularly for correct operation.

#### 4.5.1 Common Operation and Maintenance Tasks

It is useful to check whether a pump is still operating on its original pump curve. To do this it is necessary that the flow rate through the pump and the pressures on both the suction and delivery sides are measured. Ensure that the flow meter and pressure gauges are in good condition and accurate.

Operate the pump and take readings on the flow meter as well as the two pressure gauges. Determine the pumping head by subtracting the suction pressure from the delivery pressure (if the suction pressure is a negative it will thus be added). Then plot the flow rate and delivery pressure on the pump's head-flow curve that should be on record, or can be obtained from manufacturers. If this point plots on or close to the original pump curve, the pump is still operating on its original curve. It is possible to obtain a few points on the pump curve in this way by throttling a valve on the delivery side of the pump and then repeating the procedure above. If the power consumption of the pump motor can be measured, the efficiency of the pump can also be calculated and plotted. If the measured heads and flow rates do not plot close to the original pump curve, further investigations are warranted. A first step must be to verify that the flow and pressure meters give accurate readings. If the problem persists it may be necessary to service the pump or have the pump curve verified commercially. If pump flow rate varies, for instance when used under different operational conditions or pumping directly into a supply area, the operating point of the pump should be determined under the different conditions. The different operational efficiencies can then be determined by plotting these points on the pump curve.

### 4.5.2 Common Pump Problems

Table 2 gives a useful description of common pump problems, possible causes and remedies, developed by the Southern African Pump Systems Development Association (SAPSDA, www.sapsda.co.za).

Note that work on pumps can be very dangerous, and thus it is critically important to obtain and follow all applicable safety guidelines before doing any such work.

**Common pump problems, possible causes and remedies (SAPSDA, www.sapsda.co.za)**

| SYMPTOM | PROBABLE FAULT | REMEDY |
|---|---|---|
| Pump does not deliver liquid | Impeller rotating in wrong direction. | Reverse direction of rotation by swapping two phases on the electrical supply. |
| | Pump not properly primed - air or vapour lock in suction line. | Stop pump and reprime. |
| | Inlet of suction pipe insufficiently submerged and sucking a vortex in the water. | Increase suction depth of suction pipe to at least 3 x diameter of suction pipe. |
| | Air leaks in suction line or gland arrangement. | Make good any leaks or repack gland. |
| | Pump not up to rated speed. | Increase speed. |
| | Delivery/suction valve throttled or not fully opened or completely shut. | Check valve position. |
| Pump does not deliver rated quantity | Air or vapour lock in suction line. | Stop pump and reprime. |
| | Inlet of suction pipe insufficiently submerged and sucking a vortex in the water. | Increase suction depth of suction pipe to at least 3 x diameter of suction pipe. |
| | Pump not up to rated speed. | Increase speed by adjusting drive pulley ratios or use a variable speed drive. |
| | Air leaks in suction line or gland arrangement. | Make good any leaks or repack gland. |
| | Foot valve or suction strainer choked. | Clean foot valve or strainer. |
| | Restriction in delivery pipe work or pipe work incorrect. | Clear obstruction or rectify error in pipe work. |
| | Head underestimated and/or pump incorrectly selected. | Check head losses in delivery pipes, bends and valves, reduce losses as required or re-select pump to required delivery rate. |
| | Unobserved leak in delivery. | Examine pipe work and repair leak. |
| | Blockage in impeller or casing. | Remove half casing and clear obstruction. |
| | Excessive wear at neck rings or wearing plates. | Dismantle pump and restore clearances to original dimensions. |

| SYMPTOM | PROBABLE FAULT | REMEDY |
|---|---|---|
| | Impeller damaged or vane angles not to specification. | Dismantle pump and renew impeller or re-machine vane angles. |
| | Pump gaskets leaking. | Renew defective gaskets. |
| | Suction/delivery or non return valves faulty or not fully open. | Check valves for defects replace if necessary. |
| Pump does not generate its rated delivery pressure | Impeller rotating in wrong direction. | Reverse direction of rotation by swapping two phases on the electrical supply. |
| | Pump not up to rated speed. | Increase speed by adjusting drive pulley ratios or use a variable speed drive. |
| | Impeller neck rings worn excessively. | Dismantle pump and restore clearances to original dimensions. |
| | Impeller damaged or choked. | Dismantle pump and renew impeller or clear blockage. |
| | Pump gaskets leaking. | Renew defective gaskets. |
| Pump loses liquid after starting | Suction line not fully primed - air or vapour lock in suction line. | Stop pump and reprime. |
| | Inlet of suction pipe insufficiently submerged. | Increase suction depth of suction pipe to at least 3 x diameter of suction pipe. |
| | Air leaks in suction line or gland arrangement. | Make good any leaks or renew gland packing. |
| | Liquid seal to gland arrangement lantern ring (if fitted) orifice choked. | Clean out liquid seal supply orifice. |
| | Lantern ring not properly located. | Unpack gland and relocate lantern ring under supply orifice. |
| Pump overloads driving unit | Pump gaskets leaking. | Renew defective gaskets. |
| | Serious leak in delivery line, pump delivering more than its rated quantity. | Repair leak or choke the pump with the delivery valve to ensure that it runs on it's curve. |
| | Speed too high. | Reduce speed. |
| | Bearings defective. | Replace bearing. |

| SYMPTOM | PROBABLE FAULT | REMEDY |
| --- | --- | --- |
| | Impeller neck rings worn excessively. | Dismantle pump and restore clearances to original dimensions. |
| | Gland packing too tight. | Stop pump, close delivery valve to relieve internal pressure on packing, slacken back the gland nuts and retighten to finger tightness. |
| | Impeller damaged. | Dismantle pump and renew impeller. |
| | Mechanical tightness at pump internal components. | Dismantle pump, check internal clearances and adjust as necessary. |
| | Pipe work exerting strain on pump. | Disconnect pipe work and realign to pump. |
| | Misalignment between drive and pump. | Align pump and drive. |
| | Pumping a product with a different density than what the pump was designed for (sludge vs water). | Check for what liquid the pump was designed for. Change the liquid product or change the pump. |
| Bearings wear | Pump and driving unit out of alignment. | Disconnect coupling and realign pump and driving unit. |
| | Rotating element shaft bent. | Replenish with correct grade of oil or drain down to correct level. |
| | Dirt in bearings. | Drain out bearing, flush through bearings; refill with correct grade of oil. |
| | Lack of lubrication. | Dismantle, clean out and flush through bearings; refill with correct grade of oil. |
| | Bearing badly installed. | Drain out bearing, flush through and refill with correct grade of oil. Determine cause of contamination and rectify. |
| | Pipe work exerting strain on pump. | Ensure that bearings are correctly bedded to their journals with the correct amount of oil clearance. Renew bearings if necessary. |
| | Deterioration of the oil lubricating properties due to ingress of dirt, moisture and excessive heat | Clean out old grease and repack with correct grade and amount of grease. |
| | Excessive vibration. | Disconnect pipe work and realign to pump. |

| SYMPTOM | PROBABLE FAULT | REMEDY |
| --- | --- | --- |
| Excessive vibration | Air or vapour lock in suction. | Stop pump and reprime. |
| | Inlet of suction pipe insufficiently submerged. | Increase suction depth of suction pipe to atleast 3 x diameter of suction pipe. |
| | Pump and driving unit incorrectly aligned. | Disconnect coupling and realign pump and driving unit. |
| | Worn or loose bearings. | Dismantle and renew bearings |
| | Impeller choked or damaged. | Dismantle pump and clear or renew impeller. |
| | Rotating element shaft bent. | Dismantle pump and straighten or renew shaft. |
| | Foundation not rigid or baseplate holding down bolts loose. | Remove pump, strengthen the foundation and reinstall pump. Tighten holding down bolts and fit lock nuts. |
| | Foundation/Pump plinth not large enough. | Foundation/pump plinth to be increased to roughly 5 x the weight of the pump and motor combination. |
| | Cavitation due to implosion of air bubbles. | Ensure that there is sufficient NPSH (Net Positive Suction Height) available. Bring the pump closer to the suction surface. |
| | Foundation/Pump plinth not wide enough. | Drop a vertical line from the center of the motor, two lines radiating out thirty degrees from this center-line should pass through the baseplate, not the sides of the foundation. Increase the width of the foundation. |
| | Coupling damaged. | Renew coupling. |
| | Harmonic vibration from nearby equipment. | The pump, or one of its components can vibrate in harmony with another piece of equipment located in close proximity. Isolate the vibration by installing vibration dampers. |
| | Pipework exerting strain on pump. | Disconnect pipe work and realign to pump. |
| | Shaft Alignment out. | Re-align. |

| SYMPTOM | PROBABLE FAULT | REMEDY |
|---|---|---|
| Bearing overheating | Pump and driving unit out of alignment. | Disconnect coupling and realign pump and driving unit. |
| | Oil level too low or too high. | Replenish with correct grade of oil or drain down to correct level. |
| | Wrong grade of oil. | Drain out bearing, flush through bearings; refill with correct grade of oil. |
| | Dirt in bearings. | Dismantle, clean out and flush through bearings; refill with correct grade of oil. |
| | Moisture in oil. | Drain out bearing, flush through and refill with correct grade of oil. Determine cause of contamination and rectify. |
| | Bearings too tight. | Ensure that bearings are correctly bedded to their journals with the correct amount of oil clearance. Renew bearings if necessary. |
| | Too much grease in bearing. | Clean out old grease and repack with correct grade and amount of grease. |
| | Pipework exerting strain on pump. | Disconnect pipe work and realign to pump. |
| Irregular delivery | Air or vapour lock in suction line. | Stop pump and reprime. |
| | Fault in driving unit. | Examine driving unit and make good any defects. |
| | Air leaks in suction line or gland. | Make good any leaks or repack gland. arrangement. |
| | Inlet of suction pipe insufficiently immersed in liquid. | Increase suction depth of suction pipe to at least 3 x diameter of suction pipe. |
| | Suction inlet mesh blocked or dirty. | Clean suction inlet. |
| Excessive noise level | Air or vapour lock in suction line. | Stop pump and reprime. |
| | Inlet of suction pipe insufficiently submerged. | Increase suction depth of suction pipe to at least 3 x diameter of suction pipe. |
| | Air leaks in suction line or gland arrangement. | Make good any leaks or repack gland. |

| SYMPTOM | PROBABLE FAULT | REMEDY |
| --- | --- | --- |
| | Pump and driving unit out of alignment. | Disconnect coupling and realign pump and driving unit. |
| | Worn or loose bearings. | Dismantle and renew bearings. |
| | Rotating element shaft bent. | Dismantle pump, straighten or renew shaft. |
| | Foundation or baseplate not rigid. | Remove pump and driving unit strengthen foundation. |
| | Cavitation due to pump not operating on it's designed duty point. | Throttle the pump delivery valve to force the pump back onto its operating curve. Select another pump to fit with the required duty. |
| | Waterhammer due to sudden pump stoppage. Sudden valve closure, etc. | Design pipeline and pump station components to minimize water hammer over pressures or release excess pressure to atmosphere by mechanical means. |
| | Mechanical seal arrangement has come loose from the pump shaft. | Stop the pump and replace the seat. Remachine pump shaft in case of serious damage. |
| | Mechanical seal faces are running dry causing a high pitched whistling noise. | Ensure that the pump is fully primed and avoid running the pump without water or fluid in the volute. |
| | The pump is being operated at a critical speed. (Any object made of an elastic material has a natural period of vibration. At the speed at which the centrifugal force exceeds the elastic restoring force the rotating element will vibrate as though it were seriously unbalanced - if it runs at that speed without restraining forces the deflection will continue until the shaft fails.) | Avoid operation of the pump at the critical speed or ensure that there are sufficient restraining measures in place to deal with the unbalanced forces. |

**4.6 Maintenance of fittings and other appurtenances**

**4.6.1 Valves**

The main types of valves found in a distribution system include: :

1. Isolation valves
2. Air valves
3. Scour valves

4. Non-return or check valves

**MODULE 5.0 Control valves**

**5.1 Isolation Valve Maintenance**

Maintenance requirements of isolation valves include the following:

• Valves should be ***inspected and maintained*** on regular bases, but at least once a year. Gate valves should be checked for leaks around the stem and flange gaskets. Nuts and bolts should be tightened, avoiding over-tightening. The valve body should be cleaned and corrosion protection applied when necessary. The valve stem and nut should be lubricated. Seals and gaskets should be replaced every five years.

• Isolation valves should be ***exercised (opened and closed) at regular intervals*** to ensure they are operational and don't get stuck.

• ***Valves with gearboxes*** should be serviced once a year, replacing gland packing and cracking the valve (close it slightly before opening it again) at least once a year. However, critical valves in the system should be inspected at more regular intervals to ensure they are ready should it become necessary to operate them.

**5.2 Air valves**

Air valves experience two common problems: blocking of the orifice and the floater getting stuck. Thus air valves should be checked at least every six months and maintained at regular intervals. Air valve should never be isolated or removed from the pipeline while the pipe is operational as the absence of the air valve may result in damage to the pipeline.

It is recommended that spare air valves be used to immediately replace valves removed for maintenance purposes. The removed valve can then be opened, cleaned and lubricated in a workshop. Corrosion on the outside of the valve should be removed and the valve sealed with appropriate epoxy paint.

Air valve chambers should be regularly inspected to ensure that air valves are not submerged by rainwater or a pipe leak, their isolation valves open, the valve chamber air vents open and insect screens intact.

**5.3 Scour Valve**

Adequate erosion protection should be provided near the valve to avoid damage by the drainage water. The scour valve should be inspected, cleaned of plant material and debris, and tested at least once per year.

**5.4 Non-Return Valves**

Non-return valves generally have to be removed from the pipe for inspection and maintenance work, but don't need much attention. However, it is important to check that they still seal well from time to time, particularly on pump bypasses where a leaking non-return valve can cause significant reductions in pump efficiency.

## 5.5 Control valve

These valves are used to control pressure in the distribution system. They include pressure reducing valve, pressure sustaining valve, flow control valve, level control valve, surge control valve and pump control valve.

Control valves must be kept clean from dirt and insects, especially the breather holes on the valves and pilots. They should be inspected at least twice a year (more for large control valves) and serviced every three years.

**Control Valves**

## 5.6 Maintenance of Fire Hydrant

1. Hydrants in high fire-risk areas should be ***inspected*** on a regular basis and in other areas annually to ensure they are ready to perform in case of a fire emergency.
2. Hydrants should be ***serviced and their flow rate checked*** to comply with the required flow rate at least once per year. Obstacles and plants around hydrants should be cleared. The hydrant box or chamber should be cleaned of sand and debris, and the valve opened to check that it operates correctly. Stems and nozzles should be checked and flange bolts tightened if necessary. The hydrant body should be cleaned and corrosion protection applied if required.

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