सत्यमेव जयते

OPERATION AND MAINTENANCE MANUAL FOR RURAL WATER SUPPLIES

Government of India

Ministry of Drinking Water and Sanitation

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पंकज जैन, आई.ए.एस
PANKAJ JAIN I.A.S.

सत्यमेव जयते

सचिव
भारत सरकार
पेयजल एवं स्वच्छता मंत्रालय
Secretary
Government of India
Ministry of Drinking Water and Sanitation
247, 'A' Wing, Nirman Bhawan, New Delhi-110108
Tel. : 23061207, 23061245 Fax : 23062715
E-mail : secydws@nic.in
Website : www.ddws.nic.in

FOREWORD

Much progress has been made in providing water supply facilities in rural India. By 2012 India had reached safe drinking water supply to about 85 % of 850 million rural people in 1.6 million rural habitations. Given the scale of the challenge, this is a considerable achievement. However, services still require improvement. A large portion of habitations face challenges associated with source sustainability, water quality or operation and maintenance.

Under the new National Rural Drinking Water Program (NRDWP, 2009) and the Strategic Plan 2011-2022, the Ministry of Drinking Water and Sanitation has set out a framework for planning, implementation and management of drinking water schemes to ensure drinking water security, institutional and financial support, and capacity building. The Strategic Plan 2011-22 prepared by the Ministry sets an ambitious target of coverage of 55 percent households with piped water supply and 35% with household connection by 2017, and 90 percent households and 80% households respectively by 2022. The Twelfth Plan (2012-2017) also emphasizes provision of piped drinking water supplies in rural areas to achieve improved service delivery.

At the same time, it is recognized that many households in rural India still rely on basic infrastructure such as dug wells and hand pumps with chronic problems of water quality due to poor sanitation and hygiene. Establishing behavior change to ensure open-defecation free villages remains the first step towards provision of safe drinking water.

In March 2011, the Ministry of Drinking Water and Sanitation as part of its mandate to provide technical assistance to states released the Operation and Maintenance Manual to help States to operate, maintain drinking water supply schemes. This updated Operation and Maintenance Manual provides further technical and managerial information on the process and content through which village level water supply schemes are operated and maintained to ensure improved and sustainable service delivery. It takes into account the current aspirations and challenges facing the sector, and builds on the framework already set out in the NRDWP, the 12th Five Year Plan approach and Strategic Plan 2011-2022.

The efforts and inputs from Shri T.M. Vijay Bhaskar, Joint Secretary (DWS) and his technical team comprising of Dr. Dinesh Chand, Additional Adviser , Shri D. Rajshekhar, Dy. Adviser, Shri R.L. Mathur, Asst. Adviser, Shri A.G. Shanmuga Sundaram, Consultant (Water) and other officers of the Ministry and also the Officers from various State Govt. Departments, PHEDs, Boards who participated actively during two Workshops held in Hyderabad and Delhi for finalization of this Manual and offered valuable comments/ suggestions to improve the quality of this Manual are highly appreciated and acknowledged gratefully. The valuable contributions from WSP/ World Bank, New Delhi and TWAD Board, Chennai in initial drafting and finalization process are also acknowledged.

This Manual will be of assistance to State, district, block and village level personnel engaged in the delivery of rural drinking water to achieve sustainable improved service delivery. Further, it is hoped that the state officials /PRIs technicians engaged in O & M of drinking water supply schemes would certainly be benefitted and guided by this manual in providing satisfactory level of water supply services using the O & M funds optimally and effectively.

Pankaj Jain

New Delhi
25th April 2013

T.M. Vijay Bhaskar, I.A.S.
Joint Secretary
टी.एम. विजय भास्कर, आई.ए.एस
संयुक्त सचिव

भारत सरकार
पेयजल एवं स्वच्छता मंत्रालय
राजीव गांधी राष्ट्रीय पेयजल मिशन
Government of India
Ministry of Drinking Water and Sanitation
Rajiv Gandhi National Drinking Water Mission

सत्यमेव जयते

MESSAGE

Operation and Maintenance (O & M) Manual for Rural Water Supplies was prepared and released by this Ministry in March, 2011. Thereafter suggestions were received from States to make it more practical and user friendly to field level engineers. The Twelfth Five Year Plan document has now laid emphasis on piped water supply at 55 lpcd with focus on household connections. With these developments in mind, it was decided to update this O & M Manual and make it more useful to field level engineers and panchayats.

Water and Sanitation Programme-South Asia (WSP-SA) of World Bank, TWAD Board, Chennai and engineers of various State Public Health Engineering Departments who gave written comments as well as those who participated in the workshops held for this purpose have contributed immensely in preparing this manual. I am grateful to WSP-SA, TWAD Board and State PHEDs for their contribution. The team comprising of Dr. Dinesh Chand, Additional Adviser, Shri D. Rajasekhar, Deputy Adviser, Shri G. Balasubramanian, Deputy Adviser, Shri R.L. Mathur, Assistant Adviser (Retainer), Shri Shanmugam, Consultant and other officers of this Ministry have ably put together all the suggestions and have minutely gone through the draft to fine-tune it and bring it to the final shape.

I hope that States would use this Manual to prepare small booklets in local languages for dissemination to field level engineers/ gram panchayats. This Manual would then become more useful in operation of water supply systems and lead to improved drinking water supply delivery.

TMVijayBhaskar

(T.M. Vijay Bhaskar)

ग्रामीण क्षेत्रों में
पेयजल स्थायित्व एवं सम्पूर्ण स्वच्छता

Sustainable Drinking Water and
Sanitation for all in Rural Areas

Paryavaran Bhawan, 9th Floor, CGO Complex, Lodhi Road, New Delhi-110003
Tel. : 24361043 Fax : 24364113 E-mail : jstm@nic.in

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CHAPTER -1

INTRODUCTION

1.1 Objectives of Operation and Maintenance

The objective of an efficient operation and maintenance of a water supply system is to provide safe drinking water as per designed quality and quantity, with adequate pressure at convenient location and time at competitive cost on a sustainable basis

“Operation refers to timely and daily operation of the components of a Water Supply system such as headwork’s, treatment plant, machinery and equipment, conveying mains, service reservoirs and distribution system etc., effectively by various technical personnel, as a routine function.”

“Maintenance is defined as the act of keeping the structures, plants, machinery and equipment and other facilities in an optimum working order. Maintenance includes preventive /routine maintenance and also breakdown maintenance. However, replacements, correction of defects etc. are considered as actions excluded from preventive maintenance.

1.2 Sector Organization

Water supply and sanitation is treated as a State subject as per the Constitution of India and, therefore, the States are responsible for the planning, Implementation, operation and cost recovery of water supply and sanitation projects. At the local level, the responsibility is entrusted by legislation to the local bodies like Gram Panchayat / Village water & sanitation Committee (VWSC) in Rural Sector.

The Public Health Engineering Department (PHED)/ Water Supply & Sanitation Boards (WSSBs) / Nigams are the principal agency at the State level for planning and implementation of water supply program.

The Ministry of Drinking Water and Sanitation, Government of India formulates policy guidelines in respect of Rural Water Supply & Sanitation Sector and provides technical assistance to the States & Rural Local Bodies (GPs/VWSC) wherever needed. The expenditure on rural water supply is met out by Ministry of Drinking Water and Sanitation under National Rural Drinking Water Programme NRDWP as well as State Government and also with loans from National/International financial institutions.

1.3 Operation& Maintenance Scenario

It has been observed that lack of attention to the important aspect of Operation & Maintenance (O&M) of water supply schemes in several villages often leads to their dysfunction or deterioration of the useful life of the systems necessitating premature replacement of many components, incurring huge losses. As such even after creating such assets by investing millions of rupees, they failed to provide the proper services effectively to the community for which they have been constructed and became dysfunctional or remained underutilized most of the time.

Some of the key issues contributing to the poor Operation & Maintenance (O&M) have been Identified as follows:

- Lack of finance, equipment, material, and inadequate data on Operation & Maintenance
- Inappropriate system design; and inadequate Workmanship
- Multiplicity of agencies, overlapping responsibilities.

- Inadequate operating staff
- Illegal tapping of water
- Inadequate training of personnel.
- Lesser attraction of maintenance jobs in carrier planning.
- Lack of performance evaluation and regular monitoring.
- Inadequate emphasis on preventive maintenance
- Lack of O & M manual.
- Lack of real time field information etc.

Therefore, there is a need for clear–cut sector policies and legal framework and a clear demarcation of responsibilities and mandates for O & M of water supply schemes.

1.4 Necessity for Manual

The Manual on Operation and Maintenance is a long felt need of the rural drinking water sector. At present, there is no technical manual on this subject to benefit the field personnel and to help the O& M authorities to prepare their own specific manuals suitable to their organizations.

As per the 73th Amendment to the Constitution, all the rural water supply schemes are to be operated and maintained by local bodies (V.W.S.Cs./G.Ps./Z.P./civil societies), therefore, this operation and maintenance manual has been prepared to facilitate/institutionalize the operation and maintenance system of rural water supply schemes.

1.5 How Can A Village Improve Its O&M?

Efficient and effective operation depends upon sound village water supply strategies made up of (a) water safety plans to ensure good quality water, (b) standard operating procedures including who will do what and when, and to identify associated annual expenses and revenues; and (c) service improvement plans to set out future investments to ensure improved, sustainable service delivery.

1.5.1 Water Safety Plans

The Water Safety Plan Shift the focus from end-of-pipe testing to improved operational management, with water quality testing used to verify outcomes. They provide a means of prioritizing improvement programme based on health outcomes. Most importantly, water safety plans address bacteriological contamination which is the biggest water quality related threat to public health, especially infant mortality.

A water safety plan may consists sanitary surveying the water supply system from source to storage / treatment to distribution to households (also known as sanitary survey) so as to identify sources /causes of contamination and corresponding operational control measures to reduce the risks .The controls have to be monitored to check that all the components of schemes are working, otherwise remedial action should be taken accordingly.

1.5.2 Standard Operating Procedures

The Standard Operating Procedure are essential to identify what local operators should do in terms of routine O&M related to water sources, conveying ,pumping, storage and treatment units, and distribution systems including household connections. Annual budgets of operating expenses and income, and annual surplus/deficit should be maintained. Someone with good experience and required skills would be needed to train operators and assist them when problems arise.
Often the tasks required can overwhelm a local operator who has only basic skills and limited experience, but by providing basic orientation in terms of hands on experience and build confidence to do the job well.

1.5.3 Service improvement plans

It is important to define management and, service delivery improvements and actions to improve accounts, billing and revenue collection.

CHAPTER - 2
STRATEGY

2.1 INTRODUCTION

The large investments made to construct utilities intended to provide facilities for water supply are generally becoming unproductive, mainly on account of poor Maintenance. If this situation continues even after few years, these schemes become defunct, and a large amount of money is required to replace and rebuild the system components apart from interruptions in service occur owing to the breakdown of equipment .The water supply boards /departments are not able to ensure that the maintenance staff follows valid practices of O&M. Generally the management of Water supply systems in the water authorities is receiving relatively lower priority. Further lack of funds coupled with lack of enthusiasm/motivation among the operation and maintenance staff to keep schemes in working condition; lack of staff training may be reasons for the poor status of the water supply systems.

The activities which are required for good operation and maintenance (O&M) are as follow.

2.2 Preparation of O&M Plan

A plan has to be prepared for operation and maintenance of every major unit as well as scheme as a whole. The overall operation and maintenance plan should be made scheme wise for their various individual units. This plan has to contain procedures for routine tasks, checks and inspection at set intervals viz. daily, weekly, quarterly, semi-annually or annually.

2.2.1 Development of Individual Plan for O&M

The individual plan must be prepared scheme wise for all units and all pieces of equipment. Each unit must have a plan to fix responsibility, timing of action, and ways and means. Generally actions recommended by the manufacturer or by the site engineer in charge who has installed the equipment or who has supervised the installation can be included. Often the contractor’s recommended operation and maintenance procedures at the time of design/ construction will be a good starting point for preparing sound program. This plan has to be followed by the O&M staff and also will be the basis for supervision/ inspection. It also may be used for evaluation of the O&M status and the delivery of designed outcome.

The agency in-charge for O&M of water supply shall become service oriented. It is essential that the organization responsible for O&M has well qualified, trained, experienced motivated and efficient staff to perform better.

2.2.2 Capacity building plans for O&M personnel

The training program can be organized through National or by State Resource Centers authorized by the Government of India under NRDWP in different States .The personnel who are already available or chosen to carry out the action contained in the programme may have to be trained through special courses or by “on the job training “to ensure that these personnel are thoroughly trained to carry out the action listed in the plan of maintenance. The supervisors can be trained initially who in turn may train the operators.

2.2.3Plan for providing spares and tools

It is essential to ensure the availability of spare parts like stand by pump-sets, minimum numbers of different sizes of jointing materials assessed on the basis of lengths of pipe lines, all sizes of nuts and bolts, Bearings, pipe pieces of different sizes & materials, electric spares like MCBs, Relay etc.

The availability of spare parts for repairs and replacements is to be ensured by ordering and delivery of spare parts by organizing an inventory system. The list of spare parts to be procured can be drafted on the basis of manufacturer's recommendations / consumption of material in previous years. The spare parts procured should be of BIS standard, with proper quality check.

2.2.4. Plan for water audit and leakage control

The availability of potable water (underground and surface) is very limited, There are considerable losses in the water produced and distributed through leakages in pipelines, valves, public tapes un authorized service connection etc. the percentage of unaccounted for water (UFW/NRW) ranges from 30 to 55 % .Thus, huge quantum of water is being wasted which also leads to reduction in water as well as revenue losses. Therefore it become essential to plan the conservative use of water i.e. water auditing/ leakage control through metering, improved O & M practices and awareness intervention.

2.2.5 Plan for efficient use of power

Power charges can be as high as 30 to 50 % of the total O & M cost Hence an efficient use of power and reducing wastage of power will go a long way in efficient functioning of the utility. This could be achieved by systematic energy audit which can identify the possible means to save energy and reduce power consumption apart from use of star rating equipment/Power capacitors.

2.2.6. Plan for sound financial management system

It is essential to establish a sound financial management system to make the water supply system financially viable. This can be achieved by controlling expenditure and increasing the income through preparing annual budget, based on realistic estimates.

The full cost recovery of O&M cost through user charges may be adopted. However, Gram Panchayats should have their own water tariff structure depending upon the O&M expenditure and socio-economic condition of the users.

Presently as per NRDWP guideline 15% of NRDWP funds can be used by the state/ UTs on O&M of rural drinking water supply scheme .The funding pattern for this will be on 50:50 basis between the Centre and state except for the north-East State and Jammu & Kashmir for which funding pattern is 90:10 basis.

2.2.7. Plan for Information Education Communication (IEC) conservative use of water

The IEC activities is a very essential part for conservative use of water ,The awareness for conservative use of water can be generated among consumer by plays ,electronic media ,print media and by mouth publicity . The utility organization should prepare Information- Education-Communication material and use the services of voluntary organization/NGOs to create awareness among the public and consumers.

2.2.8 Role of Voluntary /Non-Government organization (NGOs)

The Role of Voluntary /Non-Government organization (NGOs) can be important especially in the creation of public awareness on issues like water conservation, proper use of water by people and the need to pay price for water at affordable level. Water users' committee may be formed by active involvement of NGOs to periodically review the local problems, advice the agencies on improvements needed and upkeep of utilities within their jurisdiction and also encourage the people to remit water charges regularly and encourage hygienic habits.

2.2.9 Reports and Record Keeping

A Reports and Record Keeping system shall be enforced to list all the basic data of each piece of equipment and the history of the equipment .A reporting system shall be provided for the operator to inform the supervisor /manager about the problems of each equipment requiring the attention to repair and replacement crew or other specialized service personal.

The success of operation and maintenance programme should result in decline of frequency of shutdowns, and emergency repairs. Improved O&M may result increased availability water supply and more revenue, Further, the cost of repairs may also reduce with the increase of equipment's life owing to the implementation of the maintenance program.

CHAPTER -3

RURAL WATER SUPPLY SCHEMES

Historically, drinking water supply in the rural areas in India has been outside the government's sphere of influence .Community–managed open wells, private wells, ponds, have often been the main traditional sources of rural drinking water. Government of India's effective role in rural drinking water supply sector started in 1972-73with the launch of Accelerated Rural Water Supply Program (ARWSP). With the passage of time, the program was modified in 2009-10and re-named as National Rural Drinking Water Programme with the national goal to provide every rural person with adequate safe water for drinking, cooking and other domestic basic needs on sustainable basis. The basic requirement should meet minimum water quality standards and readily and conveniently accessible at all times and in all situation.

The Program has now been modified with major emphasis on ensuring sustainability of water availability in terms of portability, adequacy, convenience, affordability and equity while also adopting decentralized approach involving PRIs and community organization.

As per the strategy plan of ministry of Drinking Water and sanitation, Government of India, at least 55 % households shall be provided with service connection within their premises by 2017 and 90% households to be provided service connection by 2021. However the State Government may decide to provide more house hold connections depending on the feasibility.

3.1. Types of Rural Water Supply Schemes.

- Open wells/ Sanitary dug well/ rain water harvesting collections.
- Hand pumps schemes.
- Gravity flow piped water supply schemes.
- Power pump scheme.
- Hand pump fitted with mini power pump schemes or pump and tank scheme based on bore wells or sanitary dug wells.
- Single habitation and multi habitation piped water supply schemes based on surface and ground water.
- The sources of single village and multi habitation piped water supply schemes may be an open wells, sanitary wells, bore wells, infiltration wells, infiltration galleries, rivers, dams, reservoir, and canals.

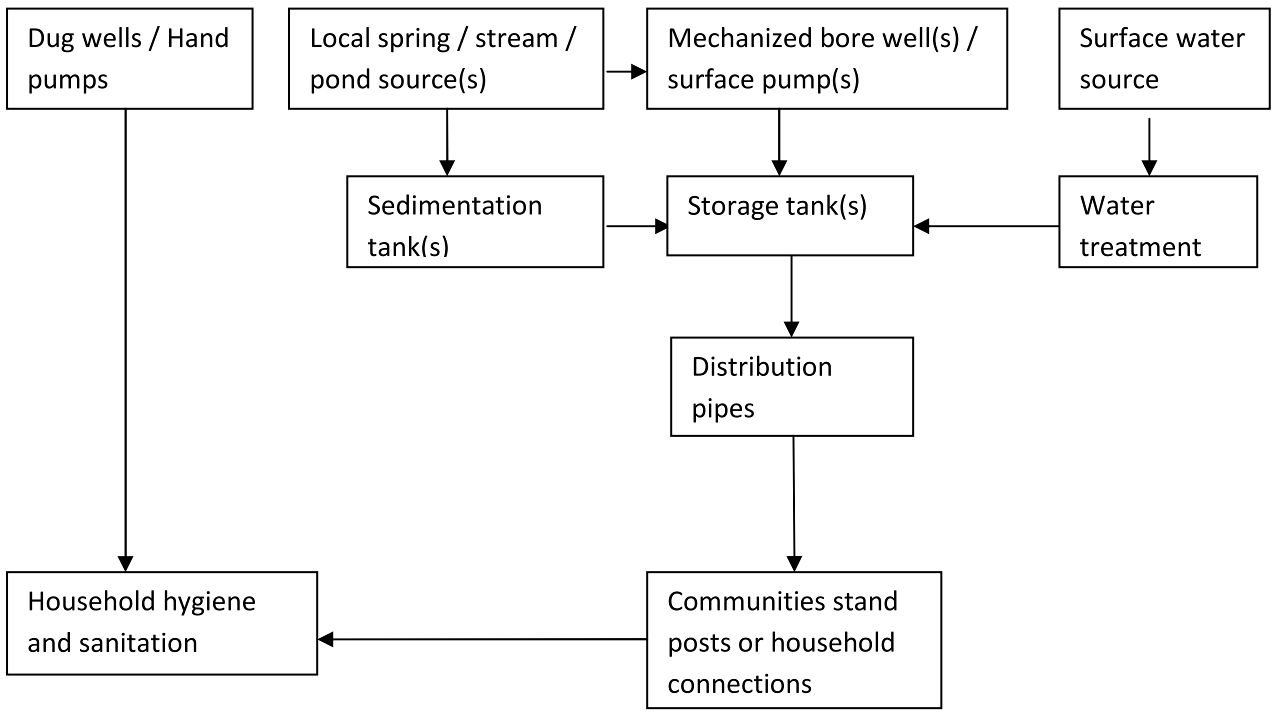
3.2 Components of Rural Piped Water Supply Scheme (PWSS)

The Rural Piped Water Supply Scheme Comprises of following components, the details of these components will be illustrated separately.

1 Source/ intake works.
2 Raw water storages.
3 Transmission System.
4 Filtration unit.
5 Pumping Machinery.
6 Disinfection.
7 Balancing Reservoir.
8 Distribution system.

9 Water testing laboratories /storage facilities & operators quarters.(depending on the size of the scheme)
10 Clear water storage/ Reservoir.

Figure 3.1: A typical flow diagram showing water supply system of different types of schemes is illustrated as below:



CHAPTER - 4

RURAL WATER SUPPLY SOURCES

Rain, snow, hail, sleet are precipitation upon the surface of the earth as meteorological water and may be considered as original sources of all the water supplied. Water, as source of drinking water, occurs as surface water and ground water. Three aspects should be considered in appraising water resources e.g. the quantity, the quality, and the reliability of available water.

4.1 Types of Sources

Following are the common water sources:

I) Surface sources –a) Rivers, canals, b) streams, c) reservoir and ponds.

ii) Sub surface sources-a) Infiltration wells, b) Infiltration galleries, local springs.

iii) Ground water sources- a) Open wells/sanitary wells/bore wells,

4.1.1 Surface Water

Surface water accumulates mainly as a result of direct runoff from precipitation (rain or snow) Precipitation that does not enter the ground through infiltration or is not returned to the atmosphere by evaporation, flows over the ground surface and is classified as direct runoff. Direct runoff is water that drains from saturated or impermeable surfaces, into stream channels, and then into natural or artificial storage sites or into the ocean in coastal areas. In addition to serving domestic water needs, a reservoir may be used for flood control process and drought mitigation, for hydroelectric power generation, and for Agriculture purposes. The quantity of available surface water depends largely upon intensity & duration of rainfall and will vary considerably between wet and dry years. Surface water supplies may be further divided into river, lake, and reservoir supplies. Dams are constructed to create artificial storage. Surface water can be conveyed from Canals/ open channels to the schemes through intake structure/ flow regulator and transmission pipes by gravity / pumping. Managing lakes and reservoir used for domestic supplies vary widely depending on local condition.

The probability of contamination of surface water is very high. The factor affecting water qualities are waste water, agriculture waste, domestic and Industrial discharge, grazing of livestock, drainage from mining area. The method of treatment of water depends upon row water quality and range from disinfection only to complete treatment.

4.1.2 Intake Structure

An Intake is a device or structure placed in a surface water source to permit withdrawal of water from this source and its discharge into an intake conduit through which it will flow into the water works system. Types of intake structures consist of intake towers, submerged intakes, intake pipes or conduits, movable intakes, and shore intakes. Intake structures over the inlet ends of intake conduits are necessary to protect against wave action, floods, stoppage.

Intake towers are used for large waterworks drawing water from lakes, reservoirs and rivers. Navigation, ice, pollution, and other interfere with the proper functioning of the intake tower due to either a wide fluctuation in water level or the desire to draw water at a depth to source water of the best quality to avoid clogging or for other reasons.

4.1.2.1 Problems & Necessary Steps In Operation

Some of the problems that may arise during the operation of Intakes are given below. Necessary steps should be taken to set right the same

a) Fluctuations in water level
b) Water withdrawal at various depths,
c) Hydraulic surges, ice, floods, floating debris, boats and barges,
d) Withdrawal of water of the best available quality to avoid pollution, and to provide structural stability
e) Operation of racks and screens to prevent entry of objects that might damage pumps and treatment facilities
f) Minimising damage to aquatic life
g) Preservation of space for Equipment cleaning, Removal and repair of machinery, Storing, movement and feeding of chemicals,
h) Screens should be regularly inspected, maintained and cleaned
i) Mechanical or hydraulic jet cleaning devices should be used to clean the screens
j) Intake structures and related facilities should be inspected, operated and tested Periodically at regular intervals
k) Proper service and lubrication of intake facilities is important
l) Operation of Gates and Valves

Some of the causes of faulty operation are as under

- Settlement or shifting of supporting structures which could cause binding of gates and Valves,
- Worn, corroded, loose or broken parts
- Lack of use
- Lack of lubrication
- Improper operating procedures
- Vibration
- Improper operating procedures
- Design errors or deficiencies
- Failure of power source or circuit failure, and
- Vandalism

4.1.2.2 Safety

When working around Intake Structures proper safety procedure involving use of electrical and mechanical equipment and water safety should be observed. Proper safety procedures should be documented and included in the manual containing the operating procedure.

4.2 Ground Water

Part of the precipitation that falls infiltrates the soil; water that drains down (percolates) reaches a level at which all the openings or voids in the earth's materials are filled with water. This zone is called as saturation zone and water is called as ground water. Part of precipitation that infiltrates into the unsaturated zone is called sub surface water. This sub surface water is used as source for infiltration wells, infiltration galleries. The ground water sources are used as follows:

1. Dug well / sanitary well with or without staining wells
2. Bore well /Tube well

4.2.1 Dug Wells/Sanitary Wells

Dug wells vary in size, shape, depth, lining and the method of raising water. Typically water is lifted by a simple bucket and rope passing over a pulley. The well may have a diameter of about 1.5 to 6meters. It may be lined for example with plain concrete/RCC/hollow concrete blocks/stones masonry /brick blocks etc. with headwall with fencing and cover to prevent spilt water, rainfall runoff, debris, people and animals from entering or falling inside. A concrete apron/platform is also critical to prevent polluted water seeping back down the sides of the well and direct water away from the well into drainage channels.

4.2.1.1 O&M Activities for a Dug Well/ Sanitary Well

The daily, Monthly and Annual activities should include the following O&M activities:

(i) Daily Activities

- Check for any debris in the well by regular visual inspection
- Clean the concrete apron
- Clear the drains
- Check that the gate is closed
- Check the condition of the rope, pulley, bucket and fence by regular visual inspection
- problems Reported to the VWSC
- Disinfection

(ii) Monthly activities

- Replace the bucket and other parts as needed
- Check the concrete apron and well seal for cracks and repair them with cement mortar
- Record the water level with a rope-scale and report to the VWSC
- Lubricate the components with grease periodically.
- De-silting of dug wells periodically as required

(iii) Annual activities

- Dewater the well and clean the bottom
- Inspect the well walls and lining and repair as needed
- Check the water level and deepen the well as needed
- Check the support posts for the pulley and repair as needed
- Record the depth of water level & depth of well with a rope scale and report the VWSC

4.2.1.2 O& M Resources for a Dug Well

Unskilled labour is required for daily tasks and for collecting user charges. Semi-skilled labour (well caretaker) is needed to carry out weekly and monthly O&M tasks; a private fitter may be needed to repair the well pulley. Skilled labour (mason) is needed to work with the caretaker on yearly O&M tasks and to repair the concrete apron and support posts for the pulley.

Materials and equipment include the bucket and rope, fencing, support posts, brush, digging and hand tools, cement, pulley and pulley shaft and bearings, and masonry tools to be provided to the caretakers.

4.2.2 Hand Pumps

The Bore hole drilled for the use of Hand Pump is generally of 125 mm diameter size, which may be fitted with variety of Hand Pump instrument. Boreholes may be fitted with a variety of pumps. The India Mark II (Figure 4.1) and the India Mark III (Village Level Operation and Maintenance) (Figure 4.2) are the most common hand pumps implemented by the Public Health Engineers.

The India Mark II is suitable for a depth of up to 50 meters. The pump body parts are extremely durable over the years. The pump achieves high discharges in the range 25-45 meters. To service a Mark II, higher skills and special tools are needed which require help from qualified mechanics at village. The Mark III - VLOM means that every time the cylinder components need replacement or maintenance, only the valve assemblies can be pulled out without taking out the riser mains. If in villages where the resources are scarce, this option can often mean little break-down time. However, the cost of riser pipes may be nearly double in Mark 3.

With all hand pumps the borehole is sealed to prevent the percolation of waste water polluting the borehole. A user friendly designed platform with drains connected to a soak pit/leach pit at least three meters from the borehole is critical. The hand pump should be mounted on top of the casing pipe of borehole (½ meter above GL) so that dirty water cannot enter into the borehole. Trainers Guide for Grass Root Level Worker Training Package on Operation and Maintenance of Hand pumps (RGNDWM, 1995) may also be referred for more details.

Following precautions are required to be taken in installation of Hand Pump:

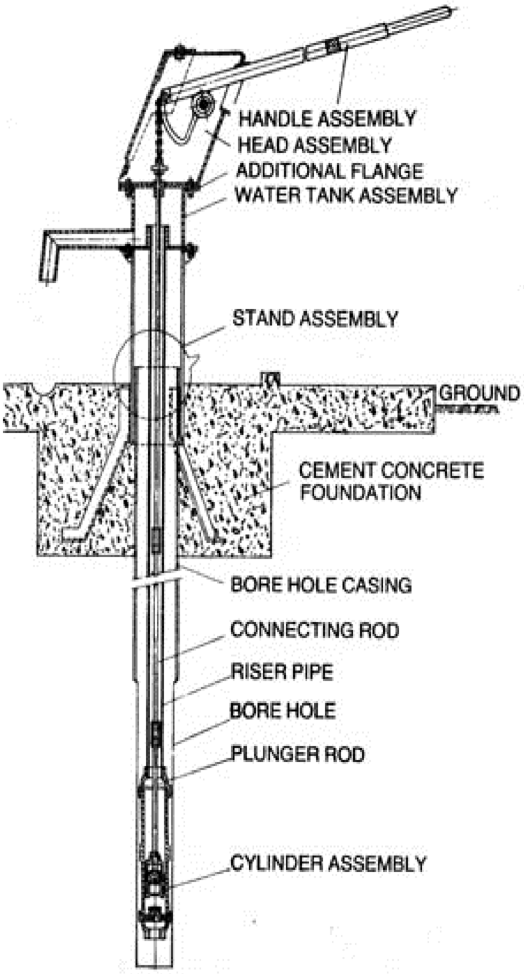
1. In the flood prone area, at least one hand pump platform should be constructed with raised platform above HFL.
2. Washing, cleaning and disinfection of bore wells are to be carried out after the flood receding situation.
3. In drought situation, water level monitoring should be done on intensity basis. Use of extra deep Hand pumps should be done. If water level goes below the limits of these hand pumps, then single phase Submersible power pumps may be installed. (Electricity / Diesel Generator)
4. Important spare parts in adequate quantities to be kept at Village level /GP level /Block level to meet the emergency situation.
5. As the water table goes down, the assembly pipes of the hand pumps may be lower down at the depth of at least 15 meter below water table. Also replace damaged pipes so as to have pipes full of water, which will lead to easy operation of hand pumps.

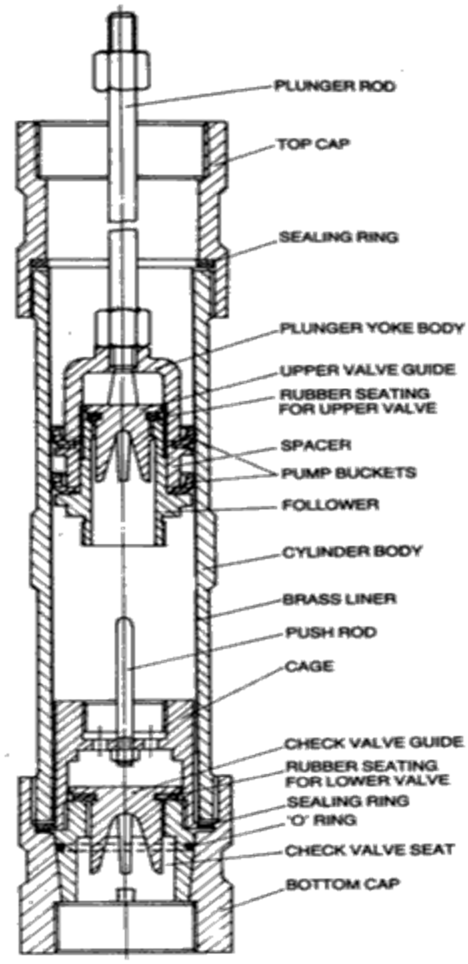
4.2.2.1 O&M activities for a hand pump

The maintenance of hand pump is identified in two categories.

Minor repairs: The repairing of hand pump which does not requires lifting of hand pump assembly is treated as minor repair. The minor repairs of hand pump may be made by a semi-skilled care taker/local PRI/village water and sanitation committee (VWSC)(this type of repairing involves replacement of handle nut &bolts, repairing of chain, bearing etc.,

Figure 4.1: India Mark II Figure 4.2: Cylinder Assembly of India Mark III Hand Pump





Major Repairs: the repairing of hand pump which involves un-lowering of hand pump assembly is treated as major repairing; this type of repairing cannot be made by local VWSC and will be carried out by hand pump mistries of Panchayat committee wherever available. Wherever Panchayat mistries are not available either special training shall be organised by line Dept. or out sourced.

The daily, Monthly and Annual activities should include the following O&M activities:

1) Weekly

- Check the fittings such as nuts, bolts and handle assembly and tighten them.
- Check the axle bolt and tighten as needed.
- Make sure the lock nut is tight.
- Make sure the hand pump is firm on its base.
- Check the flange bolts fastening the water chamber to the pedestal are tight.
- Testing water quality using a Field Test Kit.

2) Monthly Activities

- Tighten the handle axle nut and lock nut.

- Check for loose or missing flange bolts and nuts and tighten as needed.
- Open the cover and clean inside the pump.
- Check the chain anchor bolt for proper position and tighten if needed.
- Look for rusty patches, clean with a wire brush and apply anticorrosive paint.
- Find out whether the hand pump base is loose and arrange for repair of the foundation as needed.
- Measure the static water level.
- Greasing of all components.

3) Annual Activities

- Discharge is satisfactory.
- Handle is shaky.
- Guide bush is excessively worn out.
- Chain is worn out.
- Roller chain guide is excessively worn out.
- Check all parts of the hand pump for wear and tear / damages, replace damaged parts and reassemble the hand pump.
- Measure the well depth.
- All the components of the hand pump to be checked for wear and tear/damages and damaged parts replaced and hand pump re-assembled.
- Washing and cleaning of the components of the hand pumps should be done with water and bleaching powder, if required instead of mixture of water and kerosene.
- The repairs to the hand pump platforms to be done as and when needed and need not be on daily basis.

4.2.2.2 Disassembly, Inspection and Reassembly of Hand Pump

(i) Disassembly of the hand pump may be required from time to time if major problems are faced:

- Loose pump head cover bolt.
- Remove inspection cover from head assembly.
- Insert chain coupling supporting tool.
- Lift the handle to the top position and disconnect chain from handle by removing the "nylon" nut and bolt (i.e., nylon insert lock nut).
- Take out handle axle; while removing use the handle axle punch to protect the axle thread and remove the handle from the head assembly.
- Remove flange bolts from the head assembly.
- Remove head assembly from the water tank.
- Place the connecting rod vice on to the water chamber top flange and tighten vice against connecting rod and allow the head assembly to sit on the connecting rod vice.
- Disconnect the chain assembly from connecting rod.
- Support connecting rod with connecting rod lifter, loosen connecting rod vice and remove; gently lower connecting rod to sit on check valve; remove connecting rod lifter.
- Loose water tank nuts and bolts and remove water tank bottom flange bolts.
- Lift water tank by using tank pipe lifter and lifting spanners.
- Fit self-locking clamp and remove water tank.
- Join plunger assembly to check valve by turning the rod lifter in clock wise direction
- To take out water from the pipe, remove the rod lifter; join the rod lifting adaptor to the connecting rod; place head assembly over water tank and fix handle to the lifter

- Remove water from riser pipe by pushing down handle suddenly.
- Lift handle upwards slowly and disconnect connecting rod lifting adapter and take out head assembly.
- Tighten the connecting rod lifter to the connecting rod and lift the connecting rod and fix the connecting rod vice.
- Hold the connecting rod, slowly loosen the rod vice and lift the connecting rod; tighten the vice and repeat the process until it is possible to remove the connecting rod; repeat the process until the last connecting rod with plunger and check valve is pulled out.
- Separate the check valve from the plunger.
- Unscrew the plunger from the check valve.
- Remove all the parts of the check valve and clean them.

(ii) Inspection for reassembly covers the following:

- Check the water tank for leakage or damage.
- Wash and clean all parts with a mixture of water and bleaching powder.
- The stand assembly should be on a perfect level – check with a spirit level
- Check the coupler for broken threads.
- Check flanges and spout pipe for cracks and leakage.
- Check the handle axle, bearings and chain; apply grease to the bearings and chain.

(iii) Reassembly is as follows:

- Ensure parts are clean and dry, and moving parts are lubricated with oil and grease
- Check 'O' ring and cup seal and replace as needed.
- Remove cover of casing pipe for fixing stand assembly.
- Place stand assembly over casing pipe and make sure that it is vertical and check level of flange by spirit level.
- Fix water tank assembly on the stand flange by tightening the nuts and bolts.
- Join the check valve and plunger.
- Connect the plunger to the connecting rod.
- Insert the plunger assembly connected with the check valve in the riser pipe and connect the riser coupler to the water tank.
- Insert the lower end of the connecting rod in the riser pipe, and place the connecting rod over the water tank and fix it to the vice.
- Join the connecting rod pieces as per the requirement and insert in the riser pipe.
- Remove the connecting rod vice from the water tank by holding the top end of the connecting rod.
- Fix the connecting rod lifter to the top end of the connecting rod and rotate in the direction of the arrow so as to separate the check valve from the plunger and ensure that it reaches the bottom plate.
- Make a mark by hack saw on the connecting rod at the level of the water tank.
- Lift the connecting rod assembly, fix the connecting rod vice and tighten the connecting rod.
- Cut the connecting rod as per the marking after removing the connecting rod lifter.
- Smoothen with the help of a file the cut surface of the connecting rod.
- Make necessary threads on the top most end of the connecting rod.
- Fix the middle flange on the top of the water tank and ensure that all four corners coincide.
- Tighten the check nut at the top of the connecting rod.
- Screw the chain on to the connecting rod.

- Place the chain coupling supporting tool on the middle flange and remove the rod vice.
- Place the middle flange and set flanges with water tank.
- Place head assembly over the middle flange and tighten by spanner.
- Place handle assembly and insert the handle axle by handle axle punch.
- Lift the handle for fixing chain and tighten chain anchor bolt and nylon nut fully (i.e., nylon insert lock nut); remove chain coupler supporting tool by lowering the handle
- Lift handle up and apply grease on the chain.
- Lower down the handle and fix inspection cover and tighten the cover bolt fully by the crank spanner.

4.2.3 Mechanized Bore Well

4.2.3.1Tube wells and Dug wells with Pump Sets

A tube well is a type of water well in which a long 100–350 mm diameter stainless steel tube or pipe is bored into an underground aquifer. The depth of the wells depends on the depth of the water level in the Aquifer.

Boreholes may be fully cased and screened in overburden/alluvium strata and the top of the borehole shall be sealed to prevent pollution through percolation of water into the borehole. After installation of bore, the top of the borehole at the riser pipe shall be caped to prevent contamination of the borehole by surface water and debris etc. An isolation valve and non-return valve are fitted on a horizontal section of the delivery pipe, adjacent to the bore well to prevent the backflow. Typically, the pump house or fabricated panel box is located next to the borehole and housed with the control panel for operation of the electric pump. Motor service frequency in terms of running hours shall be usually specified as per catalogue and indicated to the operator. The manufacturer's O & M manuals should essentially be followed.

4.2.3.2 Preventive Maintenance

According to available data the specific yield of wells should be measured at annually and compared with the original specific yield by the trained staff/line Dept. and the record of the same shall be maintained. As soon as 10 to 15% decrease in specific yield is observed, steps should be taken to determine the cause and corrective measures should be taken accordingly. Rehabilitation procedures should be initiated before the specific yield has declined by 25%. A check list given below can be used to evaluate the performance of a well

i) Static water level in the production well
ii) Pumping rate after a specific period of continuous pumping
iii) Specific yield after a specified period of continuous pumping
iv) Sand content in a water sample after a specified period of continuous pumping
v) Total depth of the well
vi) Efficiency of the well
vii) Normal pumping rate and hours per day of operation
viii) General trend in water levels in wells in the area
ix) Draw down created in the production well because of pumping of nearby wells.

A significant change in any of the first seven conditions listed above indicates that a well or pumping rate is required. For, preventive maintenance programme well construction records showing geological condition, water quality and pumping performance shall be collected. The data of optimum and efficient limit of operation should be available which is created at the time of testing and commissioning of the well. This data is normally in the form of a discharge draw-down curve (called yield draw down curve). The pumping water level and draw down can be measured with the help of an electric depth gauge of an airline gauge.

4.2.3.3 Causes of Failure of Wells

Well may be failed due to inadequate design, faulty construction and operation, lack of timely maintenance. The main causes for source failure are categorized as under:

- Incorrect design: for instance use of incorrect size of screen and gravel pack, wrong pin pointing of well site resulting in interference.
- Poor construction e.g. the bore may not be vertical; the joints may be leaky, wrong placement of well screen, non-uniform slots of screen, improper construction of cement slurry seal to prevent inflow from Saline aquifer.
- Corrosion of screens due to chemical action of water resulting in rupture of screens.
- Faulty operation e.g. over pumping, may causes the rupture of strainer casing pipes due to piping action of water, poor maintenance.
- Adverse aquifer conditions resulting in lowering of the water table and deterioration of water quality.
- Mechanical failure e.g. falling of foreign objects including the pumping assembly and its components.
- Incrustations due to chemical action of water.
- Inadequate development of wells.
- Placement of pump sets just opposite the strainer casing pipes, causing entry of silt by rupturing slots of pipes.

4.2.3.4 Monitoring of silt coming out with water during pumping from source

Indication for silting

(i) Appearance of fine silt with water is an early indication of silting.
(ii) Reduction in depth of bore well/ opens well.
(iii) Reduction in yield of bore well.

Causes for silting

(i) Over pumping.
(ii) Improper sitting of casing pipe.
(iii) Improper jointing of casing pipes.
(iv) Placement of pump sets just opposite the strainer casing pipe.
(v) Poor development of bore wells.

Suggestions to overcome silting

(i) Periodical inspection of bore well.
(ii) Additional length of casing pipe may be inserted in the case of improper bore well assembly installation.
(iii) Flushing of bore well.
(iv) Re-development of bore well
(v) Replacement of pump sets with proper duty condition, with respect to the safe yield of the tube well.

4.2.3.5 Rejuvenation of Tube wells& Bore Wells

A decision whether to rejuvenate an old well or construct a new one based on the cost benefit analysis.

Following remedial measures can be taken for correcting situation mentioned at 4.2.3.2

4.2.3.5.1 Faulty Operation

Tube well should run in such a way that the pumping water level should always remain above the level of well screen. Over pumping will expose the well screen, which may result in incrustation and corrosion. Over pumping results in excessive draw down which may cause differential hydrostatic pressures, leading to rupture of well screen. Negligence in timely repair and maintenance may result in poor performance of the tube well. Therefore, before any permanent damage is done to tube well it should be ensured that the tube well is operated at its designed capacity and timely repair and maintenance are done

4.2.3.5.2 Adverse Aquifer Conditions

In adverse aquifer conditions where water table has depleted but the quality has not deteriorated, wells can generally be pumped with considerable reduced discharge.

4.2.3.5.3 Mechanical Failure

The falling of pumping set assembly and its components into the bore hole can be minimised by providing steel wire holdings throughout around the assembly length including pumping set or by providing and clamping a steel strip around the pumping assembly .However, in spite of proper care, sometimes foreign objects and pumping set assembly components may fall in the well. In corrosive water the column pipe joints and pump parts may get progressively weakened due to corrosion, get disconnected and fall into the well. However where well screen is not damaged, then by proper fishing the fallen objects can be taken out of the well making it functional again. Following are the one of the method taken for fishing out the fallen objects in the bore holes:

(a) ***Impression Block:*** An impression block is used to obtain an impression of the top of the object before attempting any fishing operation. Impression blocks are of many forms and design. An impression block made from a block of soft wood turned on a lathe. The diameter of the block is 2 cm less than that of drilled hole. The upper portion is shaped in the form of a pin and driven to fit tightly into the box collar of a drill pipe. To ensure further safety, the wooden block is tied with wire or pinned securely to the collar. Alternatively, the block could be fixed to a bailer. A number of nails are driven to the lower end of the block with about 1 cm of it projecting out. A sheet metal cylinder of about 5 to 7 cm is temporarily nailed around the block to hold molten wax, which is poured into it. Warm paraffin wax, soap or other plastic material poured into the cylinder is left to cool and solidify. The metal cylinder is then removed; the nail heads hold the plastic material to the block. To locate the position of a lost object, the impression block is carefully lowered into the hole until the object is reached. After a proper stamp is ensured, the tool is raised to the ground surface, where the impression made in the plastic material is examined for identifying the position of the lost object and designing or selecting the right fishing tool.

(b) ***Fishing Tools to Recover Fallen Objects:*** The term 'fish 'describes a well drilling tool, pump component or other foreign body accidentally fallen or struck in bore wells. The type and design of fishing tools required for a specific job, depends on the positioning at which it is lying in the well and the type of object to be lifted/ fished. However, series of fishing tools suitable for different jobs are available in the market, which could be adapted or modified to suit a particular requirement. The following are some of the methods of fishing process:

External catch: Fishing tools that engage the fish on its outer diameter. These tools help to recover equipment down hole by using a grapple or by threading directly to its outside surface.

Internal catch: Fishing tools that engage the fish in its inner diameter. Similar to External Catch tools, this is achieved by a grapple or by threading directly to the fish's inside surface.

4.2.3.5.4 Gripping and Releasing Mechanism

The bowl of the overshot is designed with helically tapered spiral section on its inside diameter. The gripping member (Spiral grapple or basket grapple) is fitted in to this section. When an upward pull is exerted against a fish, an expansion strain is spread evenly over a long section of the bowl and the compression strain is spread evenly over a long section of the fish. No damage or distortion occurs to either the fish or the overshot. This design permits a far stronger tool with a smaller outside diameter than is possible with an overshot that employs a single tapered section which supports slips.

A *spiral grapple* is formed as a left hand helix with a tapered exterior to conform to the helically tapered section in the bowl. Its interior is whickered for engagement with the fish.

A *Basket grapple* is an expandable cylinder with a tapered exterior to conform to the helically tapered section in the Bowl, its interior is whickered for engagement with the fish. Two types of basket grapple are available to meet the need for catching various types of fish.

The basket grapple with long catch stop has an internal shoulder located at the upper end to stop the fish the best catch position. It is designed to stop and catch collars and tool joints with sufficient length left below the grapple to allow the joint to be packed off with a Basket control packer.

Grapple controls are of two types: Spiral grapple controls are used with spiral grapples: Basket controls are used with basket grapples. Grapple controls are used as a special key to allow the grapple to move up and down during operation while simultaneously transmitting full torque from the grapple to the bowl.

Spiral Grapple controls are always plain: Basket Grapple controls may be either plain or include a pack off in addition to the pack off mill teeth is included. In operation, the overshot functions in the same manner, whether dressed with Spiral Grapple parts or Basket Grapple parts.

During the engaging operation, as the overshot is rotated to the right and lowered, the grapple will expand when the fish is engaged, allowing the fish to enter the grapple. Thereafter with rotation stopped and upward pull exerted, the grapple is contacted by the tapers in the bowl and its deep wickers grip the fish firmly.

During the releasing operation, a sharp downward pump places the larger portion of the bowl tapers opposite the grapple breaking the hold. Thereafter, when the overshot is rotated to the right and slowly elevated, the wickers will unscrew the grapple off the fish.

Operation: Engaging and pulling the fish connect the overshot to the fishing string and run it in the hole. As the top of the fish is reached, slowly rotate the fishing string to the right and gradually lower the overshot over the fish. Allow the right hand torque to stock out of the fishing string and pull on the fish by elevating the fishing string. If the fish does not come, start the circulating pumps and maintain a heavy upward strain while fluid is forced through the fish.

4.2.3.5.5 Releasing from the fish

Drop the weight of the fishing string heavily against the over shot, then simultaneously rotates to the right and slowly elevates the fishing string until the overshot is clear of the fish. To release from a recovered fish, follow the same procedure while holding fish below the overshot.

4.2.3.5.6. Rotary taper Taps

Rotary taper taps are simple, rugged, dependable internal catch fishing tools.

Operation: Run the taper tap in the hole to the top of the stuck fish. Apply less than one point of weight; rotate the tap until the tapered threads have engaged the fish. Stop rotation and pull the fish from the hole.

Rotary taper, Taps are furnished in two types: Plain or skirt type, plain taper taps do not have a skirt thread provided on the shoulder. Skin type tapers taps are threaded for a skirt. A skirt is used when the hole size is drastically different from the fish size. The taper tap can be dressed with a skirt or a skirt and oversize guide. This will allow for the taper tap to be guided in to the fish more easily during the fishing operation.

4.3.3.5.7 Maintenance of Different types of Bore wells

Sl No	Type of Borehole	Activities	Probable Cause	Suggestions
I	DTH Bore	Silting	Over pumping, reduction of yield, improper sitting of casing pipe etc.	✓ Inspection of the bore well to assess the performance of yield. ✓ Replace the pump-set of proper duty-condition match with the yield of the bore well. ✓ The appearance of fine silt with water is also an early indication of silting. ✓ Further pressing of the whole pipe assembly in the case of shallow casings will arrest the silting. ✓ In the case of hard rock bore well, flushing with compressor from the bottom will arrest/remove the silt
		Decrease in yield	Adverse seasonal conditions, clogging of pores, parallel exploitation in the neighboring well, sinking of new well in close proximity etc.	✓ Periodical flushing is essential for free flow of water ✓ Adhering to strict spacing norms to avoid interference of pumping wells. ✓ The well may also be subjected to Hydro-fracturing. (Refer CPHEEO O&M Manual p45-47) ✓ Removal of silt and clay through Chemical/acid wash. (Refer CPHEEO O&M

				Manual p39-42)
		Drying up (very low yield) of bore well	-As above-	✓ Periodical flushing, Hydro-fracturing etc. ✓ In case of defunct even after flushing it can be used as recharge well.
		Mechanical Failure	Falling of foreign objects, pump assembly etc.	✓ Mechanical devises to lift the objects. ✓ Bore hole camera can also supplement excellent information of the cause and remedy. ✓ Removal of silt and clay through Chemical/acid wash. (Refer CPHEEO O&M Manual p39-42) ✓ Sometimes re-drilling may also prove to be success. ✓ In case no remediation is possible the bore well may be utilized for recharge
Ii	DR with MS casing	Silting	Over pumping	✓ Periodical inspection of the bore well to assess the performance of the well
		Decrease in yield	Adverse aquifer condition,	✓ Periodical flushing is essential for free flow of water in the aquifer
		Mechanical Failure		As given for DTH Bore
			Incrustation/corrosion to screens etc.	✓ Removal of incrustation through Acid wash.(Refer CPHEEO O&M Manual p39-42)
		-	-	✓ Systematic chemical sampling (quality testing) of the bore water must be undertaken
		-	-	✓ Surroundings of the bore well should kept

				clean and tidy
iii	DR with RCC casing (Not common)	As narrated in DTH bore		✓ As narrated in DTH bore
Iv	For PVC casing bores(Not more than 150 mt depth)	As narrated for DR bores with MS casing		✓ As narrated in DTH bore
v	Deep & Shallow Bore	Silting Decrease in yield	Over pumping Adverse aquifer condition	✓ Periodical inspection of the bore well to assess the performance of the well ✓ Periodical flushing is essential for free flow of water in the aquifer
		Drying up of bore well	Incrustation & silting of fractures & fissures	✓ Casing should be inserted up to the weathered zone
		Mechanical Failure	Falling of foreign objects	✓ Removal of silt and clay through chemical wash
				✓ In case of drip in the yield the well may be subjected to hydro-fracturing (Refer CPHEEO O&M Manual p45-47)
				In addition, the points described under Mechanical failure in DTH bore may also be followed

4.2.3.6 Re- Development of Tube Wells

Sometimes due to carelessness at the time of construction proper development of the tube wells not done which results in constant inflow of the sand particles causing choking of the filtering media and strainers. Such tube wells need re-development. The redevelopment of tube well will have following effects:

1. Re-development of well involves removal of finer material from around the well screen, thereby enlarging the passages in the water-bearing formation to facilitate entry of water
2. Re-development removes clogging of the water-bearing formation.
3. It increases the porosity and permeability of the water-bearing formation in the vicinity of the well.
4. It stabilise the formations around the well screen so that the well will yield sand-free water.
5. Re-development increases the effective radius of the well and, consequently, its yield.

4.2.3.6.1 Methods of Re-development

Following are the methods of well re-development:

1. Over-pumping with pump.

2. Surging with surge block and bailing.
3. Surging and pumping with air compressor.
4. Back-Washing.
5. High-velocity jetting.
6. Dynamiting and acid treatment.

For rehabilitation purpose any suitable method of re-development can be used as mentioned above. The largely used method is surging and pumping with compressed air.

4.3.3.7 O & M Staff Activities of Mechanized Bore Wells

(a) Daily O&M activities:

- Clean the pump house.
- Check available Voltage in every phase.
- Check reading on ammeter is normal – stop pump if electric motor is drawing too much current and report problems, open isolation valve.
- Check power factor.
- Confirm water is being delivered.
- Check for leaks in the rising main.
- Continue to check voltmeter and ammeter readings during the day.
- Maintain pumping log book and history sheets of tools, plants & equipment's.
- Observe the abnormal sound of pumping machinery by listening the changes in noise level.

(b) Weekly activities at the tank:

- Testing water quality using a Field Test Kit (for small schemes only).

(c) Monthly activities:

- Billing and collection, and deposit with the authorities/ VWSC (for small schemes only)

(d) Annual activities may include:

- Remove the pump and rising main from the well and inspect.
- Check pipe threads and re-cut corroded or damaged threads.
- Replace badly corroded pipes.
- Inspect electric cables and check insulation between cables.
- Check as per Recommendations of manufacturer's operational manual.

4.2.3.8 O&M Resources for Mechanized Bore Wells

Semi-skilled labour (pump operator) is required for pump operation and billing and collection. Skilled labour is required for pump and motor servicing and maintenance. Materials and equipment include pipes for the rising main, tools for maintenance and repair, oil for the motor, spare parts for the motor and electrical control panel. Finances would typically be from the household paying water charges, GP or VWSC resources and Government funds.

4.2.3.9 Artificial Re-Charging of Under Ground Source

The yield in the source can be improved by artificial recharging structures. Artificial recharge of ground water can be achieved by the following:

i) Stream flow harvesting comprising of

- Anicuts
- Gully plugging /small boulder dams

- Loose stone check dams (LSCD)
- Dams

ii) *Surface flow harvesting*

- Tank
- Ponds

iii) *Direct recharge*

- Recharge of wells
- Through injected wells
- Through roof top rain water harvesting structures

Note:-The O & M of such structures may be done as per the sustainability practices and manuals

4.3.4 Infiltration Wells and Their Maintenance

Infiltration well is located in river beds where sufficient sand depth is available. These wells are sunk up to the depth where hard strata are met with. The porous concrete portion will facilitates infiltration of water in to the well. The diameter generally varies from 3 to5m. The regular inspection of infiltration well needs to be conducted.

If illegal sand mining is done around or near the well', there is the possibility of the structure getting tilted to one side. To obviate this problem', it is essential to protect the infiltration well from sand mining. Sometimes the wells may get tilted due to sand erosion during flood times and to overcome this problem packing of sand bags around the wells should be done.
It should be ensured that flood water does not enter into the well through the manhole cover during flood times and hence the manhole cover must be made water tight. Water quality test and specific yield of the well should be conducted during pre-monsoon and post monsoon period to assess the quality of water and the yields.

4.3.5 Infiltration Gallery

An infiltration gallery is a horizontal drain made from open jointed or perforated/slotted pipes, or a block drain, which is laid below the water table and collects ground water. The pipe should be driven into the well with proper slope to ensure continuous flow and the well points (horizontal drain) should be well under water table in dry season. Infiltration galleries need soils which are permeable to allow sufficient sub-surface water to be collected. The gallery should be surrounded with a gravel pack to improve flow towards it and to filter any large particles that might block the perforation. Horizontal boring at different depth and direction, in open wells is one of the types of infiltration galleries. Water collected is taken to a collection well or sump, and then either withdrawn directly or pumped to a storage tank.

Infiltration gallery is often used in conjunction with other water supply scheme as a means of increasing the quantity of water intake in areas of poor water yield in this instance one or more galleries are built which drain into the central point, such as a hand dug well or spring box. These are called *collector wells*, it is important to protect it from contamination by locating it uphill and the minimum safe distance from any source of contamination.

4.3.5.1 Sanitary inspection of Infiltration Gallery

Sanitary inspection of Infiltration Gallery is required to be conducted in once a year by water supply agency, particular attention should be paid to the catchment area of the gallery, especially with shallow galleries. The water collected in Infiltration galleries has often not had as much filtration as well or spring water thus may be more vulnerable to contamination. Water quality testing should be done twice a year, once in the wet season and once in the dry season. The water at various points in the gallery, at the collector well or sump and the distribution system should also be tested.

4.3.5.2 Maintenance of Infiltration Gallery

The following O&M aspect shall be followed:-

Never exceed the design pumping rate- not more than 60% of the yield. Higher pumping rate could cause fine sediment to enter the filter and reduce the opening size of slots and the sand may enter screen and block the part of intake opening causing more sand pumping.

1. Do not let the gallery unused for longer time since it may tend to lower the hydraulic conductivity of filter pack.
2. The maintenance of galleries involves back washing and chemical treatment. The back washing time required can be 5-10 minutes. For back washing, compressed air can also be used.

CHAPTER – 5

TRANSMISSION SYSTEM

5.1 General-Objective of Transmission System

The overall objective of a transmission system is to deliver raw water and treated water from the source to the treatment plants and treatment plants to the storage reservoirs respectively for supply into distribution networks. Transmission of raw water can be either by canals or by pipes whereas transmission of treated water is by pipes only. Transmission through pipes can be either by gravity flow or by pumping.

The objective of O&M of transmission system is to achieve optimum utilization of the installed capacity of the transmission system with minimum transmission losses and at minimum cost. To attain this objective the agency has to evolve operation procedures to ensure that the system can operate satisfactorily, function efficiently and continuously, and last as long as possible at lowest cost.

5.2 Transmission by gravity through channels or canals

5.2.1 Maintenance of Unlined Canal Transmitting Raw Water

- All grass should be scraped and weed removed from the silted bed
- Silt deposited should be removed
- Bed should be leveled and their gradient regularized.
- Berms should be kept straight by trimming
- Flow meters should be installed at the head and tail of canals at important points in between. The reading should be observed and recorded daily.
- Both edges of the bank especially the inner one should be neatly aligned and should be free from holes, weeds.
- Ensure there is no Seepage through the banks

5.2.2 Maintenance of Lined Canals Transmitting Raw Water

Cavity or pockets or any activity detected behind the lining should be carefully packed with sand or other suitable material. Care should be taken to ensure that the lining does not get damaged or displaced

Damaged portion of lining should be removed and replaced with fresh lining of good quality by preparing a thoroughly compacted sub-grade before laying fresh sub-grade. The cracks in the lining should be filed with standard sealing compound. An effective sealing may be obtained by cutting ‘V’ groove along the face of the cracks before filing with sealing compound. Packing with powdered clay upstream of the cracks my seal minor crack on the lining.

- Displaced portion of the joint filter should be removed and fresh filter material may be packed
- The chocked pressure release pipes should be cleaned by intermittent application of air and water by rodding.
- Subsoil water level should be observed regularly especially after rainy season. If there is rise, adequacy of the pressure release system or other remedial measures like humps, regulators etc. provided for the safety of the lining should be reviewed.
- Seepage through embankments if any should be observed from time to time and remedial measure should be taken.
- Silt deposition if any noticed should be flushed out during non-Monsoon period when the water is silt free.

- Aquatic weed growth if observed below the supply level should be removed. Land weed growing over the free board should also be controlled.
- Canal banks should be inspected for seepage condition at the outer slope and for some distance beyond the toe especially in high fill reaches.

5.3 Transmission through Pipes

In the case of gravity a transmission line, where direct feeding in to OHTs is envisaged then it should be ensured that design head is developed. Otherwise water will be reaching only the OHT at lower elevation at the cost of OHT at higher elevation. This can be ensured by suitably regulating the sluice valves.

All valves Installed in the transmission main should be inspected daily to ensure that there is no leakage otherwise leakage should be attended. If attending leakage requires stoppage of flow through pipes the same can be attended on a pre-fixed monthly shutdown day.

5.3.1 Types of Pipes which are generally used in Water Supply System

The various make of pipes are generally used for water supply projects. The selection and Specification of pipes should be based on field conditions and used as per the *State Pipe Policy* and *BIS specification*.

5.3.2 Problems in Transmission Mains

(i) Leakage

Water is often wasted through leaking pipes, joints, valves and fittings of the transmission system either due to bad quality of materials used, poor workmanship, and corrosion, age of the installations or through vandalism. This leads to reduced supply and loss of pressure. Review of flow meter data will indicate possible leakages. The leakages can be either visible or invisible. In the case of invisible leaks sections of pipeline can be isolated and search carried out for location of leaks.

Most common leaks are through the glands of sluice valves. Leaks also occur through expansion joints where the bolts have become loose and gland packing is not in position. Leaks through air valves occur due to improperly seated ball either due to the damage of the gasket or due to abrasion of the ball, through the gland of the isolating sluice valve or through the small orifice.

(ii)Air Entrapment

Air in free form in rising main collects at the top of the pipeline and then goes up to higher points. Here, it either escapes through air valves or forms an air pocket which in turn, results into an increase or head loss. Other problems associated with air entrainment are: surging, corrosion, reduced pump efficiency and malfunctioning of valves or vibration. In rare cases bursting of pipes also is likely to occur due to air entrainment.

There should always be air valve chamber with cover slabs for the protection of the air valve and it should always be kept leakage free and dry. Frequent inspection should be conducted to check, whether Air valves are functioning properly and to ensure that there is no leakage through air valve.

(iii) Water Hammer

The pressure rise due to water hammer may have sufficient magnitude to rupture the transmission pipe or damage the valves fixed on the pipeline. Water hammer in water supply systems occurs due to rapid closure of valves and sudden shut off or unexpected failure of power supply to the pumps. The care should be taken to open and close sluice valves gradually.

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(iv)Lack of Records/ Maps etc.

Generally, maps showing the actual alignments of transmission mains and location of other pipes & the valves on the ground may not readily be available. The location of pipes and the valves on the ground becomes difficult in the absence of such updated maps and thus, need to be prepared and updated them from time to time. Some minimum information about the location and size of pipes and valves and the direction of opening of valves etc. is required to operate and maintain the system efficiently.

5.3.3 O & M Activities

5.3.3.1 Operation Schedule

(i) ***Mapping and inventory of pipes and fitting:*** An updated transmission system map with location of valves, flow meters and pressure gauges is the foremost requirement of operation schedule. The valves indicated in the map should contain direction to open; number of turn to open, make of valve and date of fixing etc. the hydraulic gradient lines are to be marked to indicate the pressure in the transmission system. They can be used for identifying high pressure or problem areas with low pressure.

(ii) ***System pressure:*** It is essential to maintain a continuous positive pressure in the main at the time of transmission of water in the pipeline. Low pressure locations have to be investigated if necessary by measuring pressure with pressure gauge.

(iii) ***System Surveillance:*** The maintenance staff of the Department/ panchayat /VWSC should go along the transmission line frequently so as to accomplish the following objectives.

- To detect and correct any deterioration of the transmission system.
- To detect if there is encroachment of transmission system failures
- To detect and correct if there is any unauthorized tapping of water
- To detect and correct if there is damage to the system by vandalism.

5.3.3.2 Maintenance Schedule

A maintenance schedule is required to be prepared to improve the level of maintenance of water Transmission system through improved co-ordination and planning of administrative and fieldwork and through the use of adequate techniques, equipment and materials for field maintenance. The schedule has to be flexible so that it can achieve team action with the available vehicles and tools. Co-ordination of activities is required for spares and fittings, quality control of materials used and services rendered. Training of maintenance staff shall, apart from the technical skills, include training to achieve better public relations with consumers.

5.3.3.3 Activities of Maintenance Schedule

Following activities are to be included in the schedule:

i) Develop and conduct a surveillance programme for leaks in pipelines, pipe joints and valves.
ii) Develop and conduct a water quality surveillance programme.
iii) Develop and conduct a programme for locating and repairing leaks including rectifying cross connections if any, arrange for flushing, cleaning and disinfecting the mains,
iv) Establish procedures for setting up maintenance schedules and obtain and process the information provided by the public and the maintenance teams about the pipeline leaks,
v) Establish repair procedures for standard services and with provision for continuous training of the team members,

vi) Procure appropriate machinery, equipment and tools for repair of leaks and replacement of pipes and valves,
vii) Allocate suitable transport, tools and equipment to each maintenance team,
viii) Establish time, labour and material requirement and output expected, time required and other standards for each maintenance task, and
ix) Arrange for monitoring the productivity of each maintenance team

A preventive maintenance schedule has to be prepared for:

(i) Maintenance of the pipelines with particulars of the tasks to be undertaken, works not completed, and works completed,
(ii) Servicing of valves, expansion joints etc.
(iii) Maintenance of valve chambers,
(iv) Maintenance of record of tools, materials, labour, and
(v) Costs required carrying out each task.

Activities for Preventive Maintenance

a) *Servicing of valves:* Periodical servicing is required for valves, expansion joints flow meter and pressure gauges. Corrosion of valves is the main problem in some areas and can cause failure of bonnet and gland bolts. Leaks from spindle rods occur and bonnet separates from the body. Stainless steel bolts can be used for replacement and the valve can be wrapped in polythene wrap to prevent corrosion. Manufacturer's catalogues may be referred and servicing procedure should be prepared for the periodical servicing.

b) *List of spare:* List of spares procured for the transmission system shall be prepared and the spares shall be procured and kept for use. The spares may include check nut, spindle rods, bolt and nuts are flanged joints, gaskets for flanged joints for all sizes of sluice valves, consumables like gland rope, grease, cotton waste, jointing materials like rubber gaskets, spun yarn, pig-lead and lead wool etc.

c) *List of tools*: The maintenance staff shall be provided with necessary tools/equipment's for attending to the repairs in the transmission system. These tolls may include key rods for operation of sluice valves, hooks for lifting manhole covers, pipe wrench, DE spanner set, ring spanner set, screw drivers, pliers, hammers, chisels, caulking tools, crow bars, spades, dewatering pumps

5.3.4 Maintenance of Pipelines

Pipeline bursts/main breaks can occur at any time and the O & M agencies shall have a plan for attending to such events. This plan must be written down, disseminated to all concerned and the agency must always be in readiness to implement the plan immediately after the pipe breaks reported. After a pipe break is located, determine which valve is to be closed to isolate the section where the break has occurred. Some important consumers may be on the transmission system and having an industrial process dependent on water supply which cannot be shut down as fast as the water supply lines are cut off and should be notified about the break down. These consumers have to be informed about the probable interruption in water supply and also the estimated time of resumption of water supply.

After the closure of the valve the dewatering/mud pumps are used to drain the pipe breakpoints. The sides of trenches have to be properly protected before the workers enter the pit. The damaged pipe is removed, and the accumulated silt is removed from inside the pipe and the damaged pipe is replaced and the line is disinfected before bringing into use. A report shall be prepared following every pipe break about the cause of such break, the resource required

5.3.4.1 Scouring of pipeline

Scouring is done to clean the transmission lines by removing the impurities or sediment that may be present in the pipe. This is particularly essential in the case of transmission lines carrying raw water.

5.3.4.2. Leakage control

(i) Visible leaks: The maintenance staff during surveillance operation can report visible leaks found by him to his superiors. Critical areas where leaks often occur have to be identified and appropriate correct measures have to be implemented.

(ii) Invisible leaks: Lead detection equipment have to be procured for detection of non-visible leaks and action to control these leaks should be initiated to control the overall problem of water lost.

5.3.4.3 Chlorine Residual Testing

A minimum free chorine residual of 0.2 mg/lit at the receiving reservoir of a transmission system is needed to be maintained. Absence of residual chlorine could indicate potential presence of contamination in transmission system.

The following steps which are required to be taken are:

1. Testing of residual chlorine
2. Checking the chlorination equipment at the start of the transmission system.
3. Searching for source of contamination along the transmission system which has caused the increase in chlorine demands.
4. Immediate rectification of the source of contamination

5.3.5 Telemetary and Scada System

Manual collection of data and analyzing may not be helpful in large undertaking if water utilities have to aim at enhanced customer service by improving water quality and service level with reduced cost. The substitution for manual system is adaptation of Telemetary and Scada. This topic is discussed in Chapter12of this Manual.

5.3.6. Engaging Contractors for Maintenance

Due to inadequate trained O&M staff in line department/ PRIs/VWSC, the operation and maintenance of transmission system and other components of the scheme, if required, may be done by out sourcing/awarding Contracts for Comprehensive Annual Maintenance for any specified period e.g. 5 -10 years.

5.3.7. Records and Reports

1. Updated transmission system maps with alignment plans. Longitudinal sectional plans,
2. Record of daily readings of flow meter at upstream and downstream end of pipeline,
3. Record of water level of reservoir at both upstream and downstream end of transmission system.
4. Pressure reading of the transmission system.
5. Identification of persistent low pressure location along the pipeline.
6. Record of age of pipes.
7. Identify pipelines to be replaced.
8. Identify source of leaks.
9. Record of Bulk meter/water meter reading before the delivery into overhead tank.
10. Record of residual chlorine.
11. Record on when the pipeline leaks were repaired or pipe changed and the cost of materials and labour cost thereof.

CHAPTER –6
FILTRATION

The raw water available from surface water sources is normally not suitable for drinking purposes and needs treatment to produce safe and potable drinking water. Some of the common treatment processes viz. Plain sedimentation, Slow Sand filtration, and Rapid Sand filtration with Coagulation-flocculation units as essential pre-treatment units. Pressure filters and diatomaceous filters have been in use though very rarely. Roughing filters are used, under certain circumstances, as pre-treatment units for the conventional filters.

6.1 Types of Filtration Plants

The types of Filtration Plants are as follows:

A) Slow Sand Filter Plant
B) Rapid Sand Filter Plant
C) Other types of Filter Plants, which are not used commonly, are:
   1) Pressure filters-used as small treatment plant in Industries.
   2) Roughing filters-may be used to reduce load on the treatment plants. Small streams of water in the catchment areas may carry large particles and floating matter which can entrap such undesirable material prior to the storage structures of the treatment units.

(***Figure 6.1 shows typical flow pattern of a conventional treatment plant)***

6.1.1 Slow Sand Filtration-Plant

Slow sand filtration plant is most widely used in rural water supply schemes and is an effective, low cost system of water treatment if operated and managed correctly. A slow sand filter consists of an box about 3.0 meter deep rectangular or circular in shape and made of concrete or masonry The box contains supernatant water layer, a bed of filter media, an under drainage system and a set of control valves and appurtenances. It is normally one component in a treatment process which may involve preliminary settlement of solids and / or roughing filters and post chlorination.

Typically there may be two rectangular slow sand filters operating in parallel, one filter unit is kept in operation and other for maintenance. The filter units also comprise pipe fittings, under-drains and graded gravel to support the filter's sand bed. The filter units are operated by a combination of valves, inlet, inlet drainage, back-filling, emptying, filter regulation, clear water drainage, and distribution. A flow indicator is used for checking the flow rate. The turbidity of the inlet water is checked to ensure the water is of an acceptable turbidity to prevent rapid blocking of the filter. Turbidity is also measured at the outlet to check the filter is functioning properly. The supervising manager carries out daily bacteriological tests on the filtered water.

If the quality of the raw water demands provision of Sanitation tank may be incorporated in the system, for details reference may be made at Para no.6.1.2.3

6.1.1.1 Operation of Filter

6.1.1.2 Filter Cleaning

While the filter is in operation, a stage comes when the bed resistance increases forcing the operator to open the regulating valve fully and at this stage, the operator should plan the cleaning of the filter bed otherwise the filtration rate may reduce further. Indicators shall be installed showing the inlet and outlet heads, from which the head loss can be regularly checked; this gives a clear picture of the progress of choking and the nearness of the end of the filtration. Without any measurement of the head loss the only true indicator of build-up of resistance is the extent of opening of the regulating valve and the experienced operator may

be able to recognize, preliminary visual warnings by the filter bed surface condition. A slight deterioration in the treated water quality may also be an indication for cleaning needs.
To clean a filter bed, the raw water inlet valve is to be closed first, allowing the filter to discharge to the clear water well as long as possible (usually overnight). As the head in the supernatant reservoir drops, the rate of filtration rapidly decreases, and although the water above the bed would continue to fall until, it reaches the level of the weir outlet, it would take a very long time to do so. Consequently, after a few hours, the effluent delivery to the clear water valve is closed, and the supernatant water outlet is run to waste through the drain valve provided. When the supernatant water has been drained off (leaving the water level at the surface of the bed) it is necessary to lower the water within the bed still further, until it is lower down to 100 mm or more below the surface. This is done by opening the waste valve on the effluent outlet pipe. As soon as the Schmutzdecke is dry enough to handle, cleaning should start. If the filter bed is left too long at this stage it is likely to attract scavenging birds that will not only pollute the filter surface but also disturb the sand to a greater depth which may be removed by scraping.

The cleaning of the bed may be carried out by hand or with mechanical equipment. Working as rapidly as possible, they should strip off the Schmutzdecke and the surface sand adhering to it, stack it into ridges or heaps, and then remove the waste material by barrow, hand cart, basket, conveyor belt or other device. After removal of the scrapings, the bed should be smoothed to level surface. The quicker the filter bed is cleaned the less will be the disturbance of the bacteria and shorter the period of re-ripening. Provided they have not been completely dried out, the micro-organisms immediately below the surface will quickly recover from having been drained and will adjust themselves to their position relative to the new bed level. In this event a day or two will be sufficient for re-ripening.

Before the filter box is refilled, the exposed walls of the supernatant water reservoir should be well swabbed down to discourage the growth of adhering slimes and algae, and the height of the supernatant water drain and of the outlet must be adjusted. The water level in the bed is then raised by charging from below with treated water from the clear water well or from one of the other filters. As soon as the level has risen sufficiently above the bed surface to provide a cushion, the raw water inlet is gradually turned on. The effluent is run to waste until analysis shows that it satisfies the normal quality standards. The regulating valves on the effluent line will be substantially closed to compensate for the reduced resistance of the cleaned bed, and the filter will then be ready to start a new run.

During the cleaning operations precautions must be taken to minimize the chances of pollution of the filter bed surface by the laborers themselves. Such measures as the provision of boots that can be disinfected in a tray of bleaching solution should be taken. Hygienic personal behavior must be rigidly imposed, and no laborers with symptoms that might be attributable to water borne or parasitic diseases should be permitted to come into direct or indirect contact with the filter medium.

6.1.1.3 Re-Sanding

After several years' operation and, say, twenty or thirty scrapings the depth of filtering material will have dropped to its minimum designed level (usually 0.5 to 0.8 m above the supporting gravel, according to the grain size of the medium). In the original construction, a marker, such as a concrete block or a step in the filter box wall, is sometimes set in the structure to serve as an indication that this level has been reached and that sanding has become due. The filter bed consists of natural sand with an effective size (E.S.) of 0.25mm to 0.35 mm and uniform coefficient (U.C.) of 3 to 5.For best efficiency, thickness of filter bed should not be less than 0.4-0.5 meter. As a layer of 10-20 mm sand will be removed every time the filter is cleaned ,a new filters and should be provided with an initial depth of 1.0 meter .Re-sanding will then become necessary only once in 2-3 years. During the long period of the filter use/run some of the raw water impurities and some products of biochemical degradation may be carried into the sand-bed to a depth of some 0.3 to 0.5 m according to the grain size of the sand. To prevent cumulative fouling and increased resistance, this sand layer is required to be removed for re-sanding. However, it can be reused after proper washing, if desired. Usually, it is moved to one side and the new sand is added to the filter and thereafter, the old sand replaced on the top of the new one. Thus, this retains much of the active material to enable the re-sanded filter to become operational with the minimum re-ripening.

This process (of replacing old sand on the top of the new) known as "throwing over" is carried out in strips. Excavation is carried out on each strip in turn, making sure that it is not dug so deeply as to disturb the supporting gravel layers below. The removed material from the first strip is stacked to one side in a long ridge, the excavated trench is filled with new sand, and the adjacent strip is excavated, throwing the removed material from the second trench to cover the new sand in the first. When the whole of the bed has been re-sanded, the material in the ridge from the first trench is used to cover the new sand in the last strip.

In areas where sand is expensive or difficult to obtain, the surface scrapings may be washed, stored and used for re-sanding at some future date. These scrapings must be washed as soon as they are taken from the filter, otherwise, being full of organic matter, the material will continue to consume oxygen, quickly become anaerobic, and putrefy, yielding taste and odour producing substances that are virtually impossible to remove during any washing process.

Sand Washing Machines should be provided for the bigger plants. Wherever provided, these should be operated regularly to prevent accumulation of sand and also to keep the machine in working condition.

It should be kept in mind that it may be adapted to water, low in colour, turbidity and bacterial count. Under such circumstances, provision of roughing filters as a pre-treatment unit gives a good result

6.1.1.4 O&M Resources Required

(i) Unskilled labour required for re-sanding. Semi-skilled labour (care-takers) is required for plant operation. Skilled labour is required for supervision.

(ii) Materials and equipment include sand, basic tools, valve replacement and spares, flow indicator, turbidity apparatus, bacteriological testing equipment.

(iii) Finances would typically be from the household paying water charges, GP/VWSC resources and Government funds.

6.1.1.5 O& M Activities for Slow Sand Filter

a) *Daily activities*

- Check the rate of filtration on the flow indicator – adjust the rate of filtration as needed by turning the filtered water valve
- Check the water level in the filter – adjust the inlet vale as needed to maintain a constant water level
- Remove scum and floating material by further opening the inlet valve for short time
- Check the water level in the clear well
- Sample and check water turbidity – if the inflow turbidity is too high close the intake; if the outflow turbidity is too high report to the supervisor
- Testing water quality
- Complete the log book
- Testing Water Quality: Daily monitoring of water quality may be done whether it is slow sand filter or rapid sand filter. If the water supply scheme is having laboratory at the water treatment plant site, water quality testing both the raw water and treated water may be carried out daily.

b)*Weekly activities*

- Clean the water treatment plant site

c) Monthly activities

- *Shut down the filter unit* – remove scum and floating material; brush the filter walls; close the inlet, filtered water and distribution valves; drain water to 20 cm below the sand level; increase the filtration rate in the other filter to 0.2 m/h.
- *Clean the drained down filter bed* – wash boots and equipment before use; scrape upper 2-3 cm in narrow strips and remove scrapings from filter; check, and service, exposed inlet and drain valves; remove cleaning equipment and level sand surface; check and record depth of sand bed; adjust inlet box to the new sand level.
- *Re-start the filter* – open the recharge valve; check sand surface and level as needed; when water is 20 cm above the sand, open the inlet valve; open the filtered water valve and stop when filtration rate reaches 0.02 m/h; open waste valve for outflow water to flow to waste; open filtered water valve to increase filtration rate every hour by 0.02 m/h until a rate of 0.1 m/h is reached; adjust and check flow daily until safe to drink; close waste valve and open distribution valve to pass filtered water into the supply; decrease filtration rate of other filter to 0.1 m/h.
- Wash the filter scrapings and store the clean sand.

d) Annual activities

- Check if filter is water tight: close all valves and fill filter box from inlet valve until it overflows – close valve; leave for 24 hours and check if water level reduces; if filter box leaks, report for repair; open filtered water valve to fill outlet chamber and when full, close valve; leave for 24 hours and check if water level reduces; if chamber leaks, report for repair; open drain valve to empty filter; clean the clear well in the outlet chamber; restart filter as per the month clean.

e) Every two years, activities

- Re-sand the filter units – clean the filter as in a monthly filter clean; open drain valve to empty water from the sand bed; remove strip of old sand to one side; place new clean sand on top of exposed gravel, and level; place old sand on top of the new sand to the correct depth of 0.8 m in total, and level the surface; continue in strips until filter is re-sanded; adjust inlet box to new sand level. Re-start the filter as per the monthly clean plan.

f) Random checks

- Checks on the functioning of the plant by supervising staff including turbidity tests through a turbidity meter, and bacteriological tests of the filtered water.

g) Record keeping

Records have to be kept for the following activities.

- Daily Source water quality
- Daily Treated water quality
- Names of chemicals used
- Rates of feedings of chemicals
- Daily consumption of chemical and quality of water treated
- Dates of cleaning of filter feds, sedimentation tank and clear water reservoir
- The date and hour of return to full service (end of re-ripening period)
- Raw and filtered water levels (measured each day at the same hour) and daily loss

of head.

- The filtration rate, the hourly variations, if any.
- The quality of raw water in physical terms (turbidity, colour) and bacteriological terms (total bacterial count, E.Coli.) determined by samples taken each day at the same hour.
- The same quality factors of the filtered water.
- Any incidents occurring e.g. plankton development, rising Schmutzdecke, and unusual weather conditions.

6.1.2 Rapid Sand Filtration Plant

The pre-treatment units which form essential parts of a Rapid sand filtration unit and include:

(a)Aeration /Pre-sedimentation (optional),
(b) Coagulation and flocculation with rapid mixing facilities and
(c)Sedimentation unit
(d) Filtration unit

6.1.2.1 Aeration /Pre-sedimentation

Aeration

Aeration is a unit process in which air and water are brought into intimate contact. Turbulence increases the aeration of flowing streams. Aeration is used for the following purposes:

- carbon dioxide reduction (de-carbonation)
- oxidation of iron and manganese of many well waters (oxidation tower)
- ammonia and hydrogen sulfide reduction (stripping)
- Effective method of bacteria control.

Two general methods may be used for the aeration of water. The most common in use is the water-fall aerator. Through the use of spray nozzles, the water is broken up into small droplets or a thin film to enhance countercurrent air contact. In the air diffusion method of aeration, air is diffused into a receiving vessel containing counter-current flowing water, creating very small air bubbles. This ensures good air-water contact for "scrubbing" of undesirable gases from the water.

Pre-sedimentation

Sedimentation without coagulation and flocculation as part of the pretreatment process is known as pre-sedimentation and removal of coarse suspended matter (such as grit) depends merely on gravity. This type of sedimentation typically takes place in a reservoir, grit basin, debris dam, or sand trap at the beginning of the treatment process.

While sedimentation with coagulation/flocculation is meant to remove most of the suspended particles from the water before the water reaches to the filters, pre-sedimentation removes most of the sediment from the water at the pre-treatment stage and it reduces the load on the coagulation/flocculation basin and on the sedimentation chamber, as well as reducing the volume of coagulant chemicals required to treat the water.

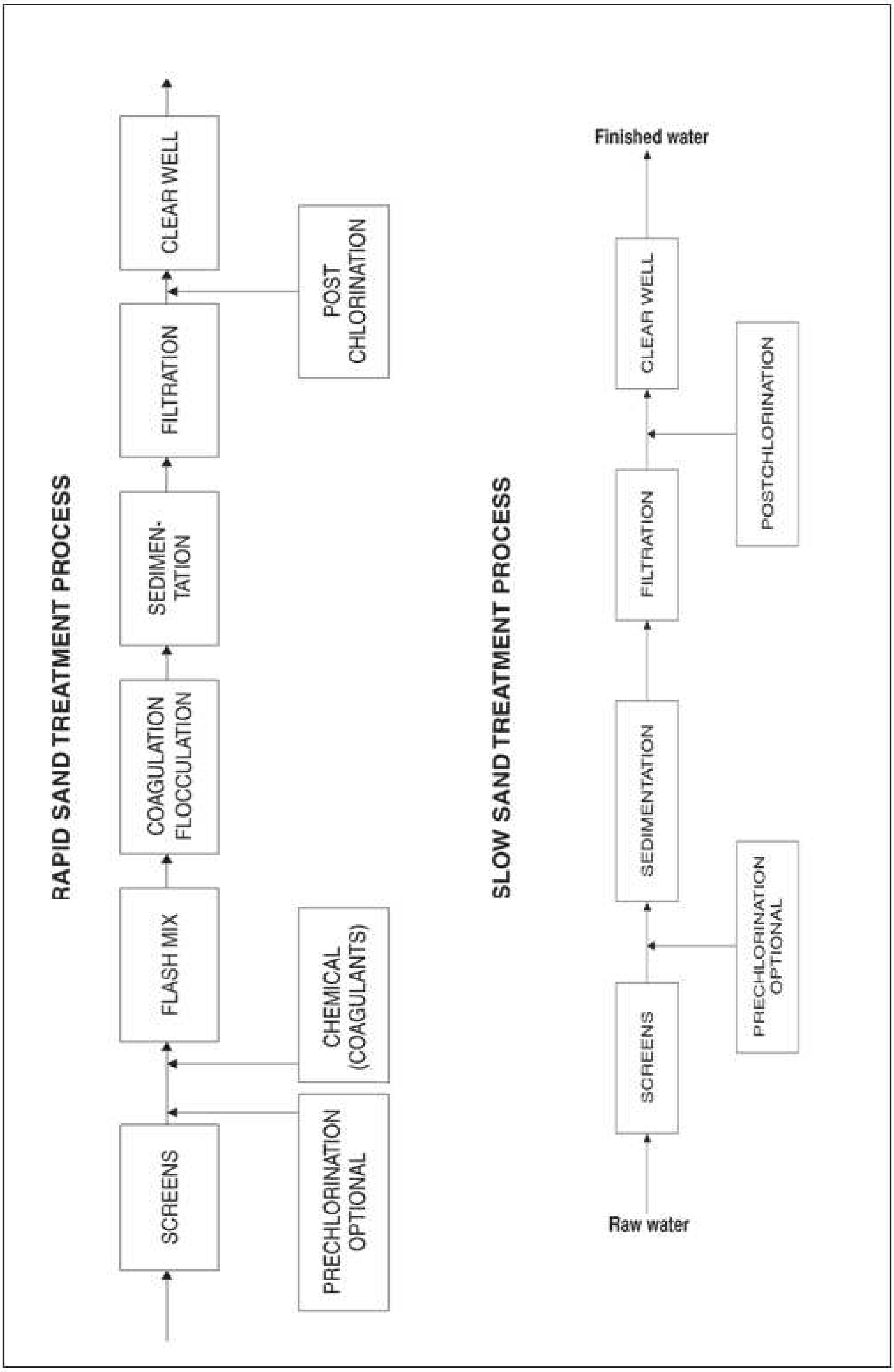
6.1.2.2 Coagulation and Flocculation

The term coagulation and flocculation are often used to describe the process of removal of turbidity caused by fine suspension, colloids and organic colours i.e. non-settleable particles from water.

Coagulation is the process by which particles become destabilized and begin to clump together. It is an essential component in the water treatment operation.

Flocculation is the second stage of the formation of settleable particles (or flocs) from destabilized colloidal sized particles and is achieved by gentle and prolonged mixing.

Fig.6.1-Conventional Filtration Process



CONVENTIONAL FILTRATION PROCESS

6.1.2.2.1 Coagulation

6.1.2.2.2 Chemical Coagulants Commonly Used in Treatment Process

The various coagulants are used in treatment process. The common coagulants used in water works practice are salt of aluminium viz. filter alumand liquid alum, sodium aluminate, Poly Aluminum Chloride (PAC), Calcium Hydroxide Calcium Oxideand chlorinated copperas which is an equi-molecular mixture of ferrous sulphate and ferric chloride being obtained by chlorinating ferrous sulphate.

The commonly used coagulant is commercial grade ferricalum (Solid), However, recently, Poly-Aluminum Chloride is also inducted as a coagulant as it gets properly dispersed, does not have any insoluble residue and effect on the settling tanks, requires less space (<50%). However, it has dis-advantage of less effective for color removal.

6.1.2.2.3 Tips for Selection of Coagulant

Coagulation is a physical and chemical reactions occurring between the alkalinity of the water and the coagulant added to the water, which results in the formation of insoluble flocs. The most important consideration is the selection of the proper type and amount of coagulant chemical to be added to raw water. Over-dosing as well as under-dosing of coagulants may lead to reduced solids removal efficiency. This condition may be corrected by carefully performed Jar tests and verifying process performance after making any change in the process of the coagulation process.

6.1.2.2.4 Dosing of the coagulant at a spot of maximum turbulence

Rapid mix of coagulant at a spot of maximum turbulence, followed by tapered flocculation in three compartmentalized units allows a maximum of mixing(reduced short circuiting), followed by a period of agglomeration intended to build larger fast settling flocs. The velocity gradient is gradually reduced from the first to the third unit (Refer CPHEEO Manual of Water supply and Treatment).

6.1.2.2.5 Mixing

The mixing is the process to mix all the coagulant in water rapidly and instantaneously especially in waters with high alkalinity so as to achieve complete homogenization of a coagulant in the water to be treated. Mixing of the coagulant can be satisfactorily accomplished in a special coagulant tank with mixing devices or in the influent channel or a pipeline to the flocculation basin with high flow velocity which produces necessary turbulence. To accomplish the mixing, following methods can be used:

- *Hydraulic mixing*
- *Mechanical mixing*
- *Diffusers and grid system*
- *Pump-blenders.*

6.1.2.2.6 Flocculation

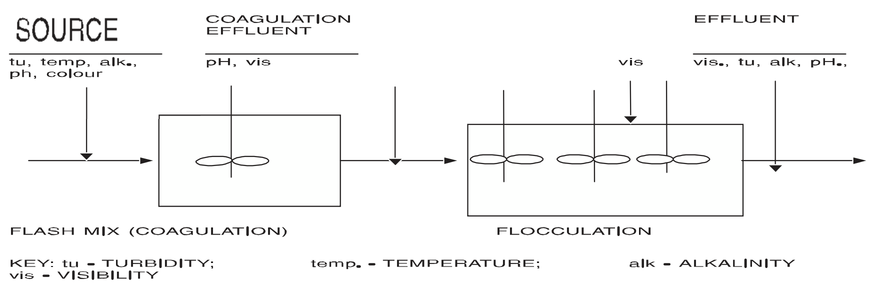
6.1.2.2.7 Flocculation Basin– Operation

The objective of a flocculation basin is to produce a settled water of low turbidity which in turn leads to reasonably longer service period of filter plant.

6.1.2.2..8 Clari-flocculator

The flocculators may be circular, square or rectangular. The best flocculation is usually achieved in a compartmentalized basin. The compartments (most often three) are separated by baffles to prevent short circuiting of the water being treated. The turbulence can be reduced gradually by reducing the speed of the mixers in each succeeding tank or by reducing the

6.2: Figure showing the overall plan of coagulation-floculation process of a typical plant.



Surface area of the paddles. This is called tapered-energy mixing. The reason for reducing the speed of the stirrers is to prevent breaking apart the larger flocs, which have already formed. If the floc is broken up nothing is accomplished and the filter gets overloaded.

short circuiting

An important factor that determines the functioning of a flocculator is the ***short circuiting***. Under such circumstances very inferior settled water is produced. Short circuiting in flocculation basins is characterized by currents which move rapidly through and continue into the settling tanks .The floc removal problem is compounded with incomplete flocculation and currents introduced into the settling process inhibit removal. Properly operated entrance, curtain baffles and exit weirs and launders can significantly improve settling.

6.1.2.2.9 Coagulation – Flocculation Process Action

Typical jobs performed by an operator in the normal operation of the coagulation-flocculation process include the following:

• Monitor process performance.
• Evaluate water quality conditions (raw and treated water).
• Check and adjust process controls and equipment, and
• Visually inspect facilities.

6.1.2.2.10 Interaction with sedimentation and Filtration

The processes of coagulation-flocculation are required to precondition or prepare non settle able particles present in the raw water for removal by sedimentation and filtration. Small particles (particularly colloids), without proper coagulation-flocculation are too light to settle out and will not be large enough to be trapped during filtration process. Since the purpose of coagulation–flocculation is to accelerate particle removal, the effectiveness of the sedimentation and filtration processes, as well as overall performance depends upon successful coagulation - flocculation.

6.2.2.2.11 Examination of the Floc

- Examine the water samples at several points, en-route the flow line of the water. Look at the clarity of the water between the flocs and study the shape and size of the flocs. Observe the floc as it enters the flocculation basins which should be small and well dispersed throughout the flow.
- Tiny alum floc may be an indication that the chemical dose is too low. A 'popcorn flake' is a desirable floc. If the water has a milky appearance or a bluish tint, the alum dose is probably too high. As the floc moves through the flocculation basins, the size of the floc should be increasing. If the size of the floc increases and then later starts to break up,the mixing intensity of the downstream flocculator may be too high. Thus, the speed of these flocculators needs to be reduced or otherwise the coagulant dosage may be increased.
- Examine the settlement of the floc in the sedimentation basin. If a lot of flocs are observed flowing over the laundering weirs the floc is too light for the detention time. By increasing the chemical dose or adding a coagulant aid such as a polymer to produce heavier and larger flocs. The appearance of the fine floc particles passing over the weir could be an indication of too much alum and the dose should be reduced. For precise evaluation only one change can be made at a time and evaluate the results.
- A summary of coagulation-flocculation process problems and how to solve them is given in table No.6.1.

6.1.2.2.12 Record keeping

Records of the following items should be maintained:

- Source water quality (pH, turbidity, temperature, alkalinity, chlorine demand and colour.
- Process water quality (pH, turbidity, and alkalinity).
- Process production inventories (chemicals used, chemical feed rates, amount of water processed, and amount of chemicals in storage).
- Process equipment performance (types of equipment in operation, maintenance procedures performed, equipment calibration and adjustments).
- A plot of key process variables should be maintained. A plot of source water turbidity vs. coagulant dosage should be maintained. If other process variables such as alkalinity or pH vary significantly, these should also be plotted.

6.1.2.2.13 Safety considerations

In the coagulation-flocculation processes, the operator may be exposed to the associated hazards with following:

- Electrical equipment,
- Rotating mechanical equipment,
- Water treatment chemicals,
- Laboratory reagents (chemicals),
- Slippery surfaces caused by certain chemicals
- Flooding.
- Confined spaces and underground structures such as valve or pump vaults (toxic and explosives gases, insufficient oxygen).

Strict and constant attention must be given to safety procedures. The operator must be trained with general first aid practices such as mouth-to-mouth resuscitation, treatment of common physical injuries, and first aid for chemical exposure (chlorine).

TABLE- 6.1: COAGULATION-FLOCCULATION PROCESS ,TROUBLE SHOOTING.

Problems	Operator Actions	Possible process changes
Source water Quality changes Turbidity	1.Perform necessary analyses to determine extent of change 2.Evaluate overall process performance 3. Perform jar tests. 4. Make appropriate process changes (see right hand column possible process changes) 5.Increase frequency of process monitoring	1. Adjust coagulant dosage. 2. Adjust flash mixer/flocculator mixing intensity. 3. Add coagulant aid or filter aid. 4. Adjust alkalinity or pH. 5.Change coagulant(s)
Coagulation process Effluent quality changes		
Turbidity Alkalinity pH	1.Evaluate source water quality 2. Perform jar tests. 3.Verify process performance: (a)Coagulant feed rate(s) (b)Flash mixer operation. 4.Make appropriate process changes	1. Adjust coagulant dosage. 2.Adjust flash mixer intensity (if possible) 3.Adjust alkalinity or pH 4.Change coagulant(s)
Flocculation Basic Floc Quality Changes		
Floc formation	1.Observe floc condition in basin: a. Dispersion. B.Size and c.Floc strength (break up) 2. Evaluate overall process performance. 3. Perform jar tests. a. Evaluate floc size setting rate and strength. B .Evaluate quality of supernatant: Clarity (turbidity) ph. And colour 4. Make appropriate process changes.	1. Adjust coagulant dosage 2.Adjust flash mixer/flocculator mixing intensity. 3. Add coagulant aid. 4.Adjsut alkalinity or ph. 5.Change Coagulant(s)

Note: All major problems should be reported to the authorities and response duly followed up.

6.1.2.2.14 Start-up and Shutdown Procedures

a) Conditions requiring Implementation of Start-up and Shutdown Procedures

These procedures generally happen when the plant is shut down for maintenance. However, on some rare instances, shut down may be required due to a major equipment failure.

b)Start-up Procedures

1) Check the condition of all mechanical equipment i.e. gear box, flash mixing equipment's, motors & rotating assembly, for proper lubrication and operational status.

2) Make sure all chemical feeders are ready. There should be plenty of chemicals available in the tanks and ready to be fed to the raw water.
3) Collect a sample of raw water and immediately run a jar test using fresh chemicals from the supply of chemicals to the feeders.
4) Determine the settings for the chemical feeders and set the feed rates on the equipment.
5) Open the inlet gate or valve to start the raw water flowing.
6) Immediately start the selected chemical feed systems.
7) Open valves to start feeding coagulant chemicals and dilution make-up water.
8) Check flow measurement at inlet.
9) Start chemical feeders.
10) Adjust chemical feeders as necessary.
11) Turn on the flash mixer at the appropriate time. You may have to wait until the
12) Tank or channel is full before turning on the flash mixer. Follow the manufacturer's instructions.
13) Start the sample pumps as soon as there is water at each sampling location. Allow sufficient flushing time before collecting any samples.
14) Start the flocculators as soon as the first basin is full of water.
15) Inspect mixing chamber and flocculation basin. Observe formation of floc and make necessary changes.
16) Remove any debris floating on the water surface.
17) Perform water quality analysis and make process adjustments as necessary.
18) Calibrate chemical feeders.
19) Note: Do not allow any untreated water to flow through the plant.

(c) Shut down Procedures

1) Close raw water gate to flash-mix chamber or channel.
2) Shut down the chemical feed systems.
3) Turn off chemical feeders. Shut off appropriate valves.
4) Flush or clean chemical feed lines if necessary.
5) Shut down flash mixer and flocculates as water leaves each process.
6) Shut down sample pumps before water leaves sampling location
7) Waste any water that has not been properly treated.
8) Lock out and tag appropriate electrical switches.
9) Dewater basins, if necessary. Waste any water that has not been properly treated.

(Note: Do not dewater below-ground basins without checking groundwater levels. Be careful that the basin may float or collapse depending on ground water, soil or other conditions.)

10) Close basin isolation gates or install stop-logs.
11) Open basin drain valves

Good records of actions taken during start/ shut down operations will assist the operation conducting future shutdowns.

6.1.2.2.15 Laboratory Tests

Water quality indicators for the operation of flocculation process include turbidity, alkalinity, chlorine demand, residual chlorine test, colour, pH, temperature, odour and appearance and need to be tested. In multi-habitation or big schemes, a provision of automatic water testing equipment or onsite laboratory at treatment plant may be established and maintained for the purpose.

6.1.2.3 Sedimentation

The purpose of sedimentation process is to remove suspended particles so as to reduce load on Filters. If adequate detention time and basin surface area are provided in the sedimentation basins, solids removal efficiencies can be achieved more than 95%. However, it may not always be the cost effective way to remove suspended solids.

In low turbidity source waters (less than about 10 NTU) effective coagulation, flocculation and filtration may produce satisfactory filtered water without sedimentation. In this case, coagulation-flocculation process is operated to produce a highly filterable tiny floc, which does not readily settle due to its small size; instead the tiny floc is removed by the filters. There is, however, a practical limitation in applying this concept to higher turbidity conditions. If the filters become overloaded with suspended solids, they will quickly clog and need frequent back washing. This can limit plant production and cause degradation in filtered water quality. Thus the sedimentation process should be operated from the standpoint of overall plant efficiency. If the source water turbidity is only 3 mg/l, and the jar tests indicate that 0.5 mg/l of coagulant is the most effective dosage, then one cannot expect the sedimentation process to remove a significant fraction of the suspended solids. On the other hand, source water turbidity in excess of 50 mg/l will probably require a high coagulant dosage for efficient solids removal and the suspended particles and alum floc should be removed by sedimentation basin.

6.1.2.3.1 Sedimentation Basins

The Basin can be divided into four zones viz. Inlet ;Settling ; Sludge and Outlet zone. The basins may be of the following types:

- Rectangular basins.
- Circular and square basins.
- High Rate Settlers (Tube Settlers).
- Solid Contact Units (Up-flow solid-contact clarification and up-flow sludge blanket clarification).

For more details a refer Manual on “Water Supply and Treatment” published by Ministry of Urban Development (1999 edition).

6.1.2.3.2 Operating Procedures

From a water quality point of view, filter effluent turbidity is a good indication of overall process performance. However, monitoring the performance of each of the individual water treatment process including sedimentation is must in order to check water quality or performance changes. Operations are considered to be normal within the operating ranges of the plant, while unusual or difficult to handle condition is abnormal operating condition. In normal operation of the sedimentation process one must monitor.

- Turbidity of inflow and out flow of Water in the Sedimentation Basin: Turbidity of inflow water indicates the floc or solids loading to the sedimentation basin while turbidity of outflow water of the basin indicates the effectiveness or efficiency of the sedimentation process. Low levels of outflow water turbidity to be achieved to minimize the floc loading on the filter.

- Temperature of inflow water is important as the water becomes colder, the settling of particles become slow. To compensate for this change, jar tests should be performed and accordingly, the coagulant dosage is to be adjusted to produce a heavier and thus a settle-able floc. Another possibility is to provide longer detention times when water demand decreases.

- Visual checks of the sedimentation process should include observation of floc settling characteristics, distribution of floc at the basin inlet and clarity of outflow settled water spilling over the weirs. An uneven distribution of floc or poorly settling floc is an indication of a raw water quality change or there is operational problem.

6.1.2.3.3 Process Actions

In rectangular and circular sedimentation basins, it is generally possible to make a judgment about the performance of the sedimentation process by observing how far the flocs are visible beyond the basin inlet. When sedimentation is working well, the floc will only be visible for short distance. When the sedimentation is poor, the floc will be visible for a long distance beyond the inlet.

In up-flow or solid-contact clarifiers, the depth of the sludge blanket and the density of the blanket are useful monitoring tools. If the sludge blanket is of normal density (measuredas milli-grams of solids per liter of water) but is very close to the surface, more sludge should be wasted. If the blanket is of unusually light density, the coagulation-flocculation process (chemical dosage) must be adjusted to improve performance.

With any of the sedimentation processes, it is useful to observe the quality of the effluent as it passes over the weir. Flocs coming over at the ends of the basin are indicative of density currents, short circuiting, sludge blankets that are too deep or high flows. The clarity of the outflow is also a reliable indicator of coagulation-flocculation efficiency. Process equipment should be checked regularly to assure adequate performance. Proper operation of sludge removal equipment should be verified each time for its operation, since sludge removal piping systems are subject to clogging. Free flowing sludge can be readily observed if sight glasses are incorporated in the sludge discharge piping. Otherwise, the outlet of the sludge line should be observed during sludge pumping. Frequent clogging of sludge pipe requires increasing frequency of sludge removal equipment and this can be diagnosed by performing sludge solids volume analysis in the laboratory. A summary of routine sedimentation process actions and its problems and remedial measures are given in Tables, table 6.2 & 6.3 respectively.

6.1.2.3.4 Tube Settlers

A set of small diameter tubes(inclined about 60°) having a large wetted perimeter relatively to wetted area when introduced in conventional sedimentation tank, provide laminar flow condition and with low surface loading rate yield good settlement of solids. The tubes which are inclined at about 60 degree found to yield good results. The tubes may be square, circular, hexagonal, diamond shaped, triangular, rectangular shaped. In most of the sedimentation tank the shape will be of thin sheets. There is also another type of settlers widely known as Lamella settlers.

6.1.2.3.5 Lamella settlers

Properly designed and constructed Lamella plate settlers require minimal operator attention. However, provisions for access and the maintenance should be considered.

Access

Lamella plate settlers basically require little maintenance. Access walk ways over the basin area if not provided already needs to be provided during maintenance depending upon the requirement of the maintaining agency.

Walkway either obstructs the installation and removal of plates directly beneath them, or if clear space is provided beneath the walkways, increase the size and construction cost of the sedimentation tank. However effluent channels of the Lamella plate system can be used to provide access to the plates for occasional inspection. Walkover the plate is possible using plywood sheets laid directly on the plates. Access to the sludge collection portion beneath the

Lamella plats is also needed. It may be ensured that a door or suitable facility is provided in the basin wall between the flocculation basin and Lamella plates.

Maintenance

Lamella plate equipment sedimentation basin does not require any adjustment by the operating staff. Normal maintenance is dependent on the materials selected for construction. Periodic disassembly of the plate pack system is recommended if painted carbon steel equipment is used. Stainless steel construction however minimizes routine maintenance. If process upset such as coagulant over dose or biological growth occurs, the basin may have to be drained and or plate cleaned with high pressure hose.

6.1.2.3.6 Record Keeping

Daily operations log of process performance and water quality characteristics should be maintained for the following records:

1. Inflow and outflow turbidity and inflow temperature.
2. Process production inventory (amount of water processed and volume of sludge produced).
3. Process equipment performance (type of equipment in operation, maintenance procedures performed and equipment calibration).

6.1.2.3.7 Sludge Handling and Disposal

(a) Sludge characteristics

Water treatment sludge is typically alum sludge, with solid concentrations varying from 0.25 to 10% when removed from a basin. In gravity flow sludge removal systems, the solid concentration should be limited to about 3%.If the sludge is to be pumped, solids concentrations should be high as 10% for readily transportation. In horizontal flow sedimentation basins preceded by coagulation and flocculation, over 50% of the floc will settle out in the first third of the basin length. Operationally, this must be considered when establishing the frequency of the operation of sludge removal equipment.

(b) Sludge Removal Systems

Sludge which accumulates on the bottom of the sedimentation basins must be removed periodically for the following reasons:

- To prevent interference with the settling process (such as re-suspension of solids due to scouring).
- To prevent the sludge from becoming septic or providing an environment for the growth of microorganisms that create taste and odour problems.
- To prevent excessive reduction in the cross sectional area of the basin (reduction of detention time).

In large-scale plants, sludge is normally removed on an intermittent basis with the aid of mechanical sludge removal equipment. However, in smaller plants with low solid loading, manual sludge removal may be more cost effective.

In manually cleaned basins, the sludge is allowed to accumulate until it reduces settled water quality. High levels of sludge reduce the detention time and floc carries over to the filters. The basin is then dewatered (drained), most of the sludge is removed by stationary or portable pumps, and the remaining sludge is removed with squeegees and hoses. Basin floors are usually sloped towards a drain to help sludge removal. The frequency of shutdown for cleaning will vary from several months to a year or more, depending on source water quality (amount of suspended matter in the water).

In larger plants, a variety of mechanical devices can be used to remove sludge including

- Mechanical rakes.
- Drag-chain and flights.
- Travelling bridge.

Circular or square basins are usually equipped with rotating sludge rakes. Basin floors are sloped towards the centre and the sludge rakes progressively push the sludge toward a centre outlet. In rectangular basins, the simplest sludge removal mechanism is the chain and flight system.

c) Sludge Disposal:-

Disposal of waste from the water treatment plants has become increasingly important with the availability of technology and the need for protection of the environment Treatment of waste solid ads to the cost of construction and operation of treatment plants.

Waste from the Water treatment plants comprise of:

i) Sludge from sedimentation of particulate matter in raw water, flocculated and precipitated material resulting from chemical coagulation, or residuals of excess chemical dosages, plankton etc.
ii) Waste from rinsing backwashing of filter media containing debris , chemical precipitates, straining of organic debris and plankton and residual of excess chemical dosages etc., and
iii) Waster from regeneration processes of ion exchange softening treatment plant containing cat -ion of calcium, magnesium and unused sodium and anion of chlorides and sulphates originally present in the regenerate.

d) Disposal Method

In continuous sludge removal, the feasibility of discharging of water treatment plant sludge to existing sewer nearby should be considered. For lime softening plant sludge, the reclamation by calcining and reuse can be explored .These sludge from clarification units using irons and aluminum coagulant can be dewatered by vacuum filtration. However the method of waste disposal shall conform to the pollution control norms.

TABLE -6 2: SUMMARY OF ROUTINE SEDIMENTATION PROCESS ACTIONS.

Monitor Process Performance and Evaluate Water quality conditions	Location	Frequency	Possible operator actions.
Turbidity	Influent/Effluent	At least once every 8 hour shift	1. Increase sampling frequency when process water quality is variable.
Temperature	Influent	Occasionally	2. Perform jar tests.
			3.Make necessary process changes: a. Change coagulant dosage. b. Adjust flash mixer/ flocculator mixing intensity. c. Change frequency of

			sludge removal. d. Change coagulant.
2. Make Visual observations			Possible operator actions.
Floc setting characteristics Floc distribution	First half of basin inlet	At least once per 8 hour shift. At least once per 8 hour shift.	1. Perform jar tests. 2. Make necessary process changes. a. Change coagulant dosage. b. Adjust flash mixer/flocculator mixing intensity. C Change frequency of sludge removal d. Change coagulant.
Turbidity (clarity) of settled water	Launders of settled water conduct	At least once per 8 hour shift. Note Depends on size of plant	
3.Check sludge removal equipment			Possible operator actions.
Noise, Vibration, Leakage, Overheating	Various	Once per 8 hour shift	1.Correct minor problems 2.Notify others of major problems.
4.Operate sludge Removal equipment			Possible operator actions.
Perform normal operations sequence Observe conditions of sludge being removed	Sedimentation Basin	Depends on process conditions (may vary from once per day to several days or more)	1.Change frequency of operation: a. If sludge is too watery, decrease frequency of operation and/or pumping rate. b. If sludge is too dense, bulks, or clogs discharge lines, increase frequency of operation and/ or pumping rate. c .If sludge is septic, increase frequency of operation and/ or pumping rate.
5.Inspect facilities			Possible operator actions.
Check sedimentation basis Observe basin water over launder weirs. Observe basin water surface Check for algae build up on basis walls and launders.	Various Various Various Various	Once every 8 hours shift. Once every 8 hours shift. Once every 8 hours shift. Occasionally	1. Report abnormal conditions. 2. Make flow changes or adjust launder weirs. 3. Remove debris from basin water surface.

TABLE-6.3:SEDIMENTATION PROCESSTROUBLESHOOTING.

1.Source Water Quality Changes	Operator Actions	Possible Process Changes.
Turbidity temperature Alkalinity pH Colour	1.Perform necessary analysis to determine extent of change. 2. Evaluate overall process performance. 3. Perform jar tests. 4. Make appropriate process changes (next column) 5.Increase frequency of process monitoring	1. Adjust coagulant dosage. 2. Adjust flash mixer/flocculator mixing intensity. 3.Change frequency of sludge removal (increase or decrease) 4. Increase alkalinity by adding line, caustic soda or soda ash. 5. Change coagulant.
2.Flocculation Process Effluent Quality changes	Operator Actions	Possible process changes.
Turbidity Alkalinity pH	1. Evaluate overall process performance. 2.Perform jar tests. 3. Verify performance o coagulation flocculation process. 4. Make appropriate process changes (next column)	1.Adjust coagulant dosage 2. Adjust flash mixer/flocculator mixing intensity. 3. Adjust improperly working chemical leader. 4. Change coagulant.
3. Sedimentation Basic Changes.		
Floc settling Rising or Floating Sludge	1.Observe floc settling characteristics: a. Dispersion b. size c.Settling rate 2. Evaluate overall process performance. 3. Perform jar tests. a. Assess floc size and setting rate. b, Assess quality of settled water (clarity and colour) 4. Make appropriate process changes(next column)	1. Adjust coagulant dosage. 2. Adjust flash mixer/floculator mixing intensity. 3. change frequency of sludge removal (increase or decrease) 4. Remove sludge from basic. 5. Repair broken sludge rakes. 6. Change coagulant.
4.Sedimentation Process Effluent Quality Changes		
Turbidity Colour	1. Evaluate overall process performance. 2. Perform jar test. 3. Verify process performance. Coagulation-flocculation process. 4.Make appropriate process changes (next column)	1. Change coagulant. 2.Adjust coagulant dosage 3. Adjust flash mixer/flocculator mixing intensity. 4.Change frequency of sludge removal (increase or decrease)

5. Up low clarifier process Effluent Quality changes.		
Turbidity Turbidity caused by sludge Blanket coming to Top due to Rainfall on Watershed.	1. Sec.4 above. 2. Open main drain valve of clarifier.	1.See 4 above (sedimentation process) 2. Drop entire water level of clarifier to bring the sludge blanket down.

Note: All major problems should be reported to the competent authorities and response duly followed up.

6.1.2.3.8 Start-up and Shutdown Procedures

In the event of requirement for shut down or start-up of processes on account of maintenance or a major equipment failure, proper procedures must be followed as per recommendations of the manufacturer of the plant and equipment. The procedures, in general, are given below:

(a) Start up Procedure

1) Check operational status, mode of operation of equipment and physical facilities:
    - Check that basin valves are closed.
    - Check that basin isolation gates are closed.
    - Check that launder weir plates are set at equal elevations.
    - Check to ensure that all trash, debris and tools have been removed from basin.
2) Test sludge removal equipment:
    - Check that mechanical equipment is properly lubricated and ready for operation.
    - Observe operation of sludge removal equipment.
3) Sedimentation basin filled with water:
    - Observe proper depth of water in basin.
    - Remove floating debris from basin water surface.
4) Start sample pumps.
5) Perform water quality analyses.
6) Operate sludge removal equipment. Be sure that all valves are in the proper position& operational.

(b) Shut down Procedures

1) Stop flow to sedimentation basin. Install basin isolation gates.
2) Turn off sample pump.
3) Turn off sludge removal equipment.
4) Shut off mechanical equipment and disconnect where appropriate.
5) Check that valves are in proper position& operational.
6) Lock out electrical switches and equipment.
7) Dewater basin, if necessary.
8) Be sure that the water table is not high enough to float the empty basin.
9) Open basin drain valves.
10) Grease and lubricate all gears, sprockets and mechanical moving parts which have been submerged immediately following dewatering to avoid seize up.

6.1.2.3.9 Equipment

(a) Types of support equipment – Operation and Maintenance

The operator should be thoroughly familiar with the operation and maintenance Instructions issued by the manufacturer for each specific equipment viz. flow meters and gauges Valves Control Systems; Water Quality monitors such as turbidity meters; Sludge removal equipment; Sludge and Sump pumps.

(b) Equipment Operation

Check the following:

- Proper lubrication and operational status of each unit.
- Excessive noise and vibration, overheating and leakage.
- Pumps suction and discharge pressure.

Safety Considerations

(i) Electrical Equipment

- Avoid electric shock.
- Avoid grounding yourself in water or on pipes.
- Ground all electric tools.
- Use a lock out and tag system for electric equipment or electrically driven mechanical equipment.

(ii) Mechanical Equipment

- Keep protective guards on rotating equipment
- Do not wear loose clothing around rotating equipment.
- Keep hands out of valves, pumps and other equipment.
- Clean up all lubricant and sludge spills.

(c) Open Surface water – filled structures

- Use safety devices such as hand rails and ladders
- Close all openings.
- Know the location of all life preservers.

(d) Valve and Pump Vaults, Sumps

- Be sure all underground or confined structures are free of hazardous atmosphere (Toxic or explosive gases, lack of oxygen)
- Work only in well ventilated structures.
- Take proper steps against flooding.

(For more details please refer to Chapter 19 - Safety Practices of CPHEEO Manual)

(e) Corrosion Control

All metallic parts which are prone to corrosion must be protected.

Corrosion can be controlled to a large extent by applying anti corrosive paints on the steel pipes at the time of construction of the tube well. Non-corrosive casing pipe and strainers (Such as PVC pipes and strainers) can also be used at the time of construction of tube well to avoid corrosion. Some commonly used paints/coatings to control corrosion are of aluminium, asphalt, red lead and coal tar. Now a day, a number of epoxy paints for this purpose are also available in the market.

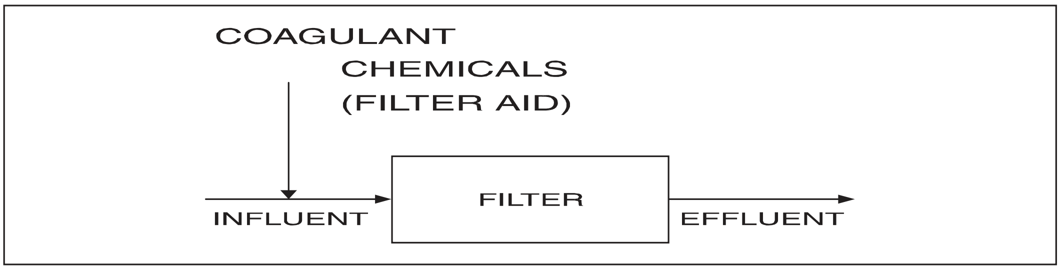


Fig. 6.4 - IN LINE FILTRATION

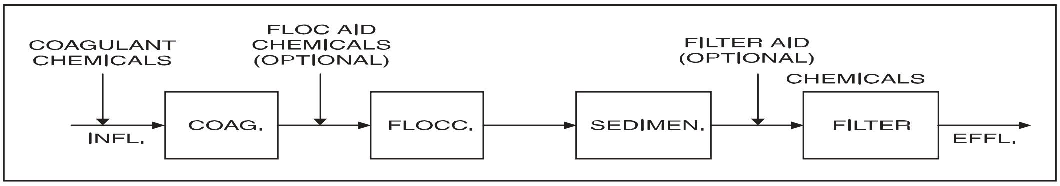


Fig. 6.5- CONVENTIONAL FILTRATION

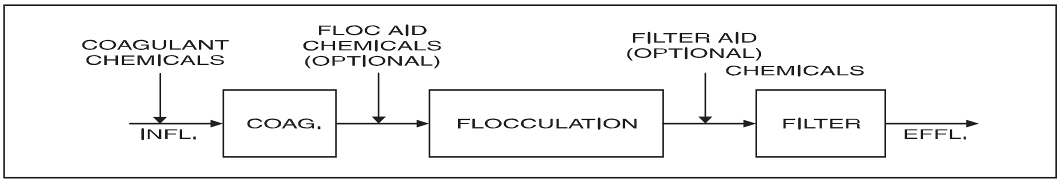


Fig. 6.6 –DIRECT FILTRATION

6.1.2.3.10 Preventive Maintenance

Such programmes are designed to assure the continued satisfactory operation of treatment plant by reducing the frequency of breakdown failures. Typical steps should include

1) Keeping electric motors free of dirt and moisture.
2) Assuring good ventilation at valve and pump vaults, sumps.
3) Checking pumps and motors for leaks, unusual noise and vibrations, overheating or signs of wear.
4) Maintaining proper lubrication and oil levels.
5) Inspecting alignment of shafts and couplings.
6) Checking bearings for overheating and proper lubrication.
7) Checking for proper valve operation.
8) Checking for free flow of sludge in sludge removal collection and discharge systems.
9) Good House Keeping.

6.1.2.4 Filter unit

Rapid Sand Filter comprises of bed of a sand serving as a single medium granular matrix supported on gravel overlying on under drainage system. The distinctive features of rapid sand filtration as compared to slow sand filtration include careful pretreatment of raw water to effectively flocculate the colloidal particles, use of higher filtration rates with more coarser & uniform filter media to utilize greater depths of filter media to trap influent solid without excessive head loss and also back washing of filter bed by reversing the flow direction to clean the entire depth of filter.

6.1.2.4.1 Filter Sand

Filter sand is defined in terms of effective size and uniformity coefficient. Effective size is the sieve size in mm that permits 10% by weight to pass. Uniformity in size is specified by the uniformity coefficient which is the ratio between the sieve sizes that will pass 60% by weight and the effective size.

Check shape size and quantity of filter sand to the followings:

- Sand shall be of hard and resistant quartz or quartzite and free of clay, fine particles, soft grains and dirt of every description.
- Effective size shall be 0.4 to 0.7 mm
- uniformity coefficient shall not be more than 1..7 nor less than 1.3
- Ignition loss should not exceed 0.7 per cent by weight.
- Soluble fraction in hydrochloric acid shall not exceed 5.0% by weight.
- Silica content should be not less than 90%
- Specific gravity shall be in the range between 2.55 to 2.65.
- Wearing loss shall not exceed 3%

(Refer IS: 8419 (Part 1) 1977 entitled Filtration Media Sand and Gravel for details).

6.1.2.4.2 Interaction with Other Treatment Processes

The purpose of filtration is to remove particulate impurities and floc from the raw water. In this regard, the filtration process is the final step in the solids removal process which usually includes the pretreatment processes of coagulation, flocculation and sedimentation. The degree of treatment applied prior to filtration depends on the quality of water.

Filter Operation and* Backwashing:* A filter is usually operated until just before clogging or breakthrough occurs or a specified time period has passed (generally 24 hours). After a filter clogs/breakthrough occurs, the filtration process is stopped and the filter is taken out of service for *cleaning or backwashing*.

Surface Wash: In order to produce optimum cleaning of the filter media during backwashing and to prevent mud balls, surface wash (supplemental scouring) is usually practiced. Surface wash systems provide additional scrubbing action to remove attached floc and other suspended solids from the filter media.

Operational Procedures

b. ***The indicators of Normal Operating Conditions:*** The filter influent and effluent turbidities should be closely watched with a turbid-meter. Filter Influent turbidity levels (settled turbidity) can be checked on a periodic basis at the filter or from the laboratory sample tap.

c. However, the filter effluent turbidity is best monitored and recorded on a continuous basis by an on-line turbidity-meter.

(b) **Process Actions*:*** Follow the steps as indicated below:

- Monitor process performance.
- Evaluate turbidity and make appropriate process changes.
- Check and adjust processes equipment (change chemical feed rates).
- Backwash filters.
- Evaluate filter media condition (media loss, mud balls, cracking),
- Visually inspect facilities.

(c) Important process activities and Precautions.

Process performance monitoring is an on-going activity. Check for any treatment process changes or other problems which might affect filtered water quality, such as a chemical feed system failure.

Measurement of head-loss built up (Refer fig.6.7) in the filter media may give a good indication of how well the solids removal process is performing. The total designed head loss from the filter influent to the effluent in a gravity filter is usually about 3 meters .At the beginning of the filtration cycle the actual measured head-loss due to clean media and other hydraulic losses are about 0.9 m. This would permit an additional head-loss of about 2.1 m due to solid accumulation in the filter.

The rate of head-loss build up is an important indication of process performance. Sudden increase in head loss might be an indication of surface sealing of the filter media (lack of depth penetration).Early detection of this condition may require appropriate process changes such as adjustment of chemical filter aid feed rate or adjustment of filtration rate.

Monitoring of filter turbidity on a continuous basis with an on-line turbidity-meter may be adopted for obtaining continuous feedback on the performance of the filtration process. In most instances it is desirable to cut off (terminate) filter at a predetermined effluent turbidity level. Preset the filter cut-off control at a point where breakthrough occurrence is noticed/ tested.

In the filter process, time for completion of normal filter process may be calculated on the basis of the following parameters:

- Head-loss.
- Effluent turbidity level.
- Elapsed run time.

- A predetermined value established for each above parameter as a cut off point for filter operation may be checked and when any of the selves is reached, the filter should be removed from service and backwashed.

- At least once a year, the filter media must be examined and evaluate its overall condition. Measure (a) the filter media thickness for an indication of media loss during the back-washing process, (b) mud ball accumulation in the filter media to evaluate the effectiveness of the overall back-washing operation.
- Routinely observe (a) the backwash process to qualitatively assess process performance, (b) for media boils (uneven flow distribution) during backwashing, media carry over in to the wash water trough, and (c) clarity of the waste wash-water near the end of the backwash cycle.

- Upon completion of the backwash cycle, observe (a)the condition of the media surface, (b) check for filter sidewall or media surface cracks (c) routinely inspect physical facilities, equipment as part of good house-keeping and maintenance practices (d) correct or report the abnormal equipment conditions to the VWSC/PRI/water agency for maintenance action.

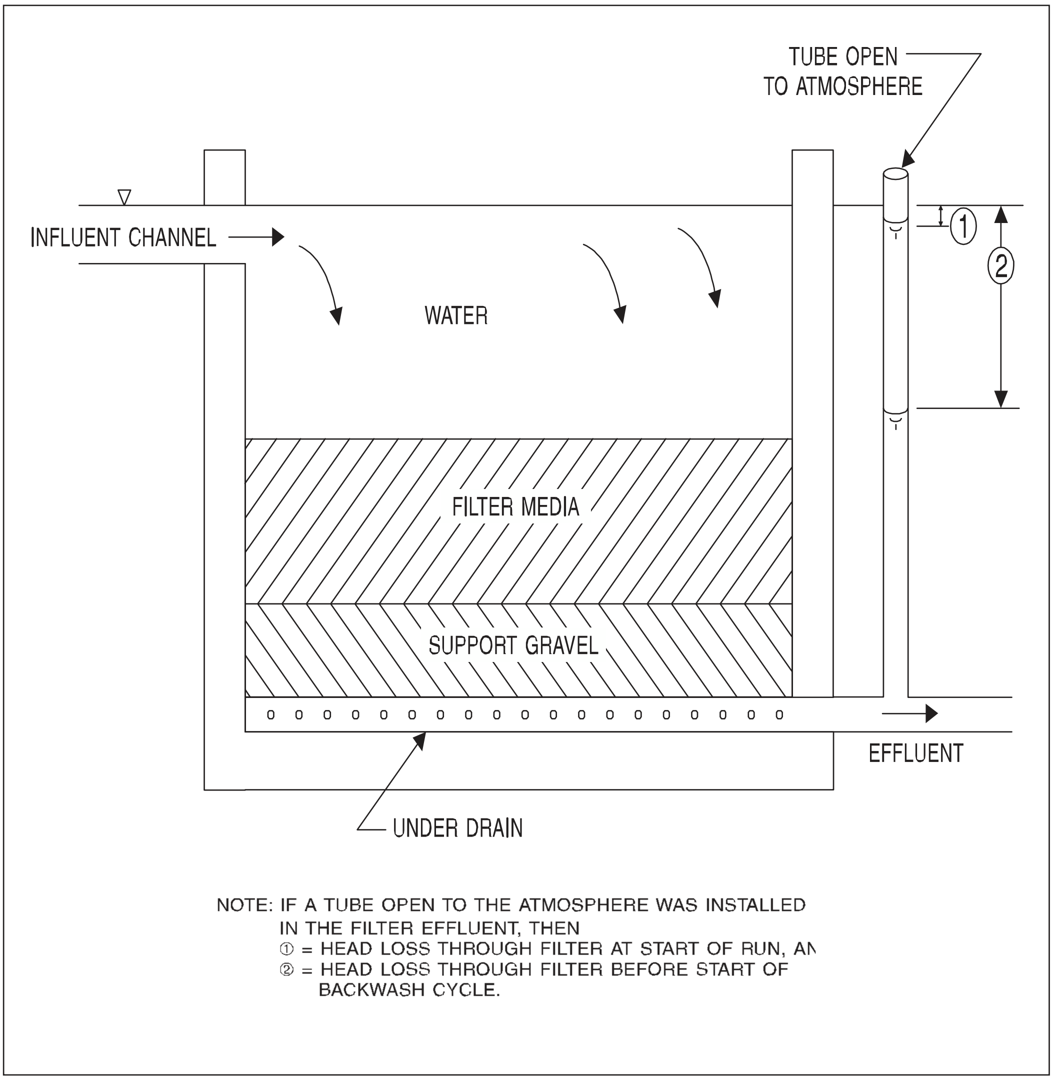


Fig. 6.7 –MEASUREMENT OF HEAD LOSS

Never bump upon filter to avoid back-washing .Bumping is the act of opening the backwash valve during the course of a filter run to dislodge the trapped solids and increase the length of filter run. This is not a good practice.

Shortened filter runs can occur because of air bound filters. Air binding will occur more frequently when large head losses are allowed to develop in the filter. Precautions should be taken to minimize air binding to avoid damage to the filter media. A summary of routine filtration process action and filtration process are given in the Tables, (Table 6.5 & 6.6).

6.1.2.4.3 Record Keeping

A daily operations log of process performance data and water quality characteristics shall be recorded and maintained accurately for the following items:

- Process water quality (turbidity, colour, PH and alkalinity).

- Process operation (filters in service, filtration rates, loss of head, length of filter runs, frequency of backwash, backwash rates, and UFRV-unit filter run volume).
- Process water production (water processed, amount of backwash water used, and chemicals used).
- Percentage of water production used to back-wash filters.
- Process equipment performance (types of equipment in operation, equipment adjustments, maintenance procedures performed, and equipment calibration).

TABLE-6.4: Summary of Routine Filtration Process Actions.

Monitor Process Performance and Evaluate Water quality conditions	**Location**	**Frequency**	**Possible operator actions.**
Turbidity	Influent/Effluent	At least once per 8 hour shift	1. Increase sampling frequency when process water quality is variable.
Colour Head Loss	Influent/Effluent	At least once per 8 hour shift At least two times per 8-hour shift	2. Perform jar tests. 3. Make necessary process changes: Adjust coagulant dosage. 4. Adjust flash mixer/ flocculator mixing intensity. 5.Change filtration rate 6.Back wash filter Change chlorine dosage 7. Change Coagulant.
Operate filters and Backwash			
Put filter into service, change filtration rate. Remove filter from service. Back wash filter, change backwash rate.	Filter module	Depends on process conditions	See operating procedure (Para 6.2.3.5)
Check filter media condition			
Media depth evaluation. Media cleanliness. Cracks or shrinkage	Filter module	At least monthly	1. Replace lost filter media. 2. Change backwash procedure. 3. Change chemical coagulants.
Make visual observations of Backwash operation			
Check for media bolls and media expansion. Check for media carryover into wash water trough. Observe clarity of waste water.	Filter module	At least once per day or whenever backwashing occurs.	1. Change backwash rate. 2. Change backwash cycle time. 3. Adjust surface wash rate or cycle time. 4. Inspect filter media and support gravel for disturbance.

Media depth evaluation. Media cleanliness. Cracks or shrinkage	Filter module	At least monthly	1. Replace lost filter media. 2. Change backwash procedure. 3. Change chemical coagulants.
Make visual observations of Backwash operation			
Check for media bolls and media expansion. Check for media carryover into wash water trough. Observe clarity of waste water.	Filter module	At least once per day or whenever backwashing occurs.	1. Change backwash rate. 2. Change backwash cycle time. 3. Adjust surface wash rate or cycle time. 4. Inspect filter media and support gravel for disturbance.
Check Filtration process and back wash equipment condition.			
Noise, Vibration, Leakage, Overheating	Various	Once per 8 hour shift	Correct minor problems.
Inspect facilities.			
Check physical facilities and algae on sidewalls and troughs.	Various	Once a day.	1.Remove debris from filter media surfaces 2.Adjust chlorine dosage to control algae.

Note: All major problems should be reported to the competent authorities and response duly followed up

TABLE 6.5: FILTRATION PROCESS TROUBLE SHOOTING

Source water quality changes	Operator actions	Possible process changes
Turbidity Temperature Alkalinity pH Colour Chlorine Demand	1. Perform necessary analysis to determine extent of change. 2.Assess overall process performance 3. Perform a jar tests. 4. Make appropriate process changes. 5. Increase frequency of process monitoring. 6.Verify response to process changes (be sure to allow sufficient time for change to take effect) 7. Add lime or caustic soda if alkalinity is low.	1. Adjust coagulant dosage. 2. Adjust flash mixer/ flocculator mixing intensity. 3.Change frequency of sludge removal (increase or decrease) 4.Adjust backwash cycle (rate ,duration) 5.Change filtration rate (add or delete Filters) 6. Start filter aid feed. 7. Change coagulant.
Sedimentation process Effluent quality changes		
Turbidity or floc carry over	1. Assess overall process performance. 2. Perform jar tests. 3. Make appropriate process changes.	Same as source water quality changes.
Filtration process change/ problems.		
Head loss increase short filter runs media surface sealing Mud balls Filter media cracks, shrinkage Filter not clean Medical bolts Media loss excessive head loss.	1. Assess overall process performance. 2. Perform jar tests. 3. Make appropriate process changes.	1. Adjust coagulant dosage. 2. Adjust flash mixer/ flocculator mixing intensity. 3.Change frequency of sludge removal (increase or decrease) 4.Adjust backwash cycle (rate ,duration) 5. Manually remove mud balls. 6. Decrease filtration rate (add more filters) 7. Decrease or terminate filter aid. 8.Replenish lost media 9. Clear under drain openings of media, corrosion or chemical deposits, check head loss. 10. Change coagulant.
Filter Effluent Quality changes		

Turbidity Breakthrough Colour pH Chlorine	1. Assess overall process performance. 2. Perform Jar tests. 3.Verify process performance: a. Coagulation and Flocculation b. Sedimentation process. c. Filtration process. 4. Make appropriate process changed.	1. Adjust coagulant dosage. 2. Adjust flash mixer/ flocculator mixing intensity. 3.Change frequency of sludge removal 4. Start filter aid feed. 5.Decrease filtration rate (add more filters) 6.Change chlorine dosage 7. Change coagulant.

Note: All major problems should be reported to the competent authorities and response duly followed up.

TABLE- 6.6: FILTERS DAILY OPERATING RECORD

No	*Time*		*Hours operated*			*Head loss*		*Wash*		*Physical condition of Filters*
	Start	*Stop*	*Today*	*Previous*	*Total*	*Start*	*stop*	*Min nn*	*M.Gal*	
1.										
2.										
3.										
4.										
5.										
6.										
7.										
8.										
9.										
10.										
11.										
No. of filters washed						*Average filter rate*				
Average run-hours						*Max. hourly rate*				
Total wash water						*Total water filtered*				

Percent of water filtered	*No. of filters operating*			
Av. Time of wash-min	*Filters out per wash-min*			
	Shift			
	Operator			

6.1.2.4.4 Start-up and Shutdown Procedures

(a)Routine Procedures

Most plants keep all filters into service except unit under backwash operation and maintenance. Filter units are routinely taken off line for backwashing when the media becomes clogged with particulates, turbidity break through occurs or demands for water are reduced.

(b) Implementation of Start-up and Shut-down Procedures

1. Filter check-out procedures

- Check operational status of filter.
- Be sure that the filter media and wash water troughs are clean of all debris such as leaves, twigs, and tools.
- Check and be sure that all access covers and walk-way gratings are in place.
- Make sure that the process monitoring equipment such as head-loss and turbidity systems are operational.
- Check the source of back-wash to ensure that it is ready to go.

2. Backwash Procedure

I) Filters should be washed before placing them into service.

- The surface wash system should be activated just before the backwash cycle starts to aid in removing and breaking up solids on the filter media and to prevent the development of mud balls. The surface wash system should be stopped before completion of the back-wash cycle to permit proper settling of the filter media.

- A filter wash should begin slowly for about one minute to permit removing of an entrapped air from the filter media, and also to provide uniform expansion of the filter bed. After this period, the full backwash rate can be applied. Sufficient time should be allowed for cleaning of the filter media. Usually when the backwash water coming up through the filter becomes clear, the media is washed. This generally takes from 3 to 8 minutes. If flooding of wash water troughs or carryover of filter media is a problem, the backwash rate must be reduced.

ii) Procedure for back-washing a filter is as follows:

- Close filter influent valve (V-1).
- Open drain valve (V-4).
- Close filter effluent valve (V-5).
- Start surface wash system (Open V-2).
- Slowly start back- wash system (Open V3). Observe filter during washing process. When wash water from filter becomes clear (filter media is clean), close surface wash system valve (V-2).
- Slowly turn off back-wash system (closeV-3). Close drain valve (V-4). Log length of wash and the quantity of water used to clean filter
- Filter Startup Procedures

- Start filter slowly open influent valve.
- When proper elevation of water is reached on top of filter, filter effluent valve should be gradually opened. This effluent control valve should be adjusted itself to maintain a constant level of water over the filter media.
- Waste some of the initial filtered water if such a provision exists.
- Perform turbidity analysis of filtered water and make process adjustments as necessary.

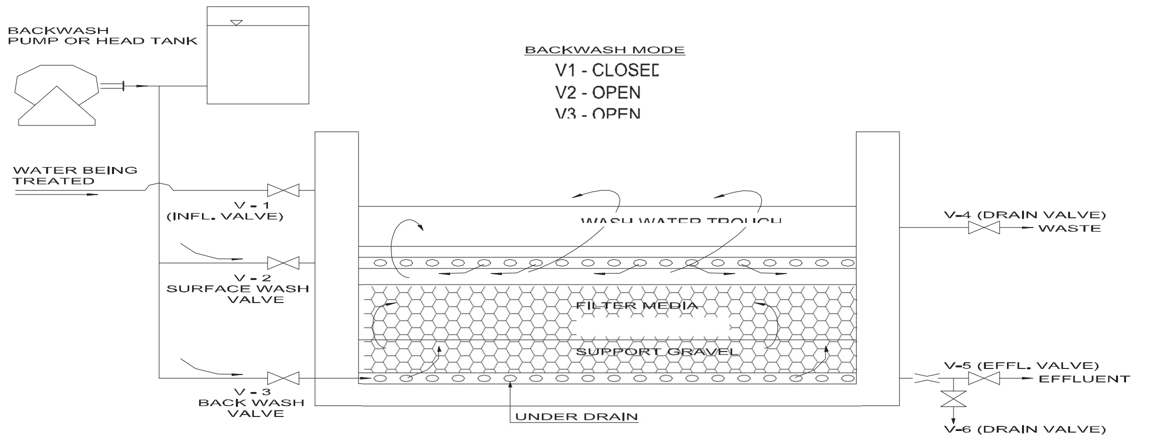


Fig. 6.8 showing the backwashing a filter

(c) Filter Shutdown Procedures

- Remove filter from service by closing influent valve and closing effluent valve Backwash filter. If filters to be out of service for a prolonged period,
- Drain water from filter to avoid algal growth.
- Note of filter in operations log.

Support Equipment

The operator must be familiar/ trained with the operation and maintenance instructions for each specific equipment item or control system.

(a) Types of Equipment

1. Filter Control Valves.
2. Backwash and surface wash pumps.
3. Flow meter and level/ pressure gauges.
4. Water quality monitors such as turbidity-meters.
5. Process monitors (head-loss and water level).
6. Mechanical and electrical filter control systems.

(b) Equipment Operation

Before starting mechanical equipment, such as a back-wash pump, the operator should be sure that the unit has been serviced as per schedule and is fit for operation. After startup, the operator should always check for excessive noise and vibrations, over-heating, and leakage (water, lubricants) otherwise, in doubt about the performance of equipment, check/refer to manufacturer's instructions. Periodical lubrication and maintenance of the equipment's are necessary.

6.1.2.4.5 Preventive Maintenance Procedures

Preventive maintenance programmes are to assure the continued satisfactory operation of treatment plant facilities by reducing the frequency of break-down failures. Routine maintenance functions of operator may include:

- Keeping electric motors free of dirt, moisture and pests (rodent sand birds).
- Assuming good ventilation (air circulation) in equipment work areas.
- Checking pumps and motors for leaks, unusual noise and vibrations or overheating.
- Maintaining proper lubrication and oil levels.
- Inspecting for alignment of shafts and couplings.
- Checking bearings for overheating and proper lubrication.
- Checking the proper valve operation (leakage or jamming).
- Checking automatic control systems for proper operation.
- Checking air/vacuum relief systems for proper functioning, dirt and moisture.
- Verifying correct operation of filters and back-washing cycles by observation.
- Inspecting filter media conditions (look for algae and mud balls and examine gravel and media for proper gradation).
- Inspecting filter under-drain system (be sure that the under drain openings are not becoming clogged due to media, corrosion nor chemical deposits).

6.1.2.4.6 Safety Considerations

(a) Electrical Equipment

1. Avoid electric shock (use preventive gloves).
2. Avoid grounding yourself in water or on pipes.
3. Ground all electric tools.
4. Lock-outandtagelectricalswitchesandpanelswhenservicingequipment.

(b) Mechanical Equipment

1. Use protective guards on rotating equipment.
2. Don't wear loose clothing around rotating equipment.
3. Keep hands out of energized valves, pumps and other pieces of equipment.
4. Clean –up all lubricant and chemicals pills (slippery surfaces cause bad falls).

(c) Open – Surface Filter

1. Use safety devices such as hand rails and ladders.
2. Close all openings and replace safety gratings when finished working.
3. Know the location of all life preservers and other safety devices.

(d) Valve and Pump Vaults, Sumps, Filter galleries

1. Be sure that all underground or confined structures are free of hazardous atmospheres (toxic or explosive gases, lack of oxygen)by checking with gas detectors.
2. Work in well ventilated structures (use air circulation fans).

CHAPTER-7
SPECIAL TREATMENT

7.1 ALGAL CONTROL

Algae are unicellular or multi-cellular chlorophyll bearing plants without any true root, stem or leaves. They may be microscopic unicellular colonial or dense mat-forming filamentous forms commonly inhabiting surface waters. Their growth is influenced by a number of factors, such as mineral nutrients, availability of sunlight, temperature and type of reservoir. During certain climatic conditions there is an algal bloom which creates acute problems in treatment processes and production of potable water. The algae commonly encountered in water purification plants are diatoms, green algae, and blue green algae and algal flagellates. Algae may be seen floating (plankton) in the form of blooms. The problems caused by algae are as follows:

1. Many species of algae produce objectionable taste and odour due to characteristic coil secretions. These also impart colour ranging from yellow-green to green, blue-green, red or brown.
2. Profuse growth of algae interferes with chemical treatment of raw water by changing water Ph and its hardness.
3. Some algae act as inhibitors in process of coagulation carried out for water purification.
4. Some algae clog filters and reduce filter run.
5. Some algae produce toxin sand their growth in drinking water reservoirs is harmful for humans and livestock.
6. Some algae provide shelter to a large number of bacteria, some of which may be pathogenic.
7. Some algae corrode metal tanks, forming pits in their walls.
8. Algae may also cause complete disintegration of concrete in contact with them.
9. Prolific growth of algae increases organic content of water, which is an important factor for the development of other organisms.

Remedial Measures

(a) Preventive Measures

Preventive measures should, therefore, be based on control of those factors such as:

- Reduction of food supply
- Change of the environment or exclusion of sunlight though they are not always practicable,
- Clear water reservoir, service reservoir s and wells may be covered to exclude sunlight ,but such a remedy is obviously inapplicable in the case of large reservoir of raw water
- Turbid water prevents large penetration and thereby reduces algal population.
- Activated carbon reduces algal population by excluding sunlight but disappearance of activated carbon in the raw water may support algal growth again.

(b) Control Measures

Adequate records of number, kind and location of algae becomes handy for algal growth control. *Algaecide* dose used should be harmless to humans, have no effect on water quality, should be inexpensive and readily available and easy to apply. The most commonly used algaecides are copper, sulphate and chlorine/ bleaching powder.

MICRO-STRAINERS

Algae can be removed from water by using micro-strainer. The infested water can be passed through stainless-steel drums with cloths of mesh size ranging from15-45 µm. Micro-straining is a useful process for the removal of filaments and colonial algae, but it does not remove smaller species or reproductive forms which can multiply later on, creating problems. Micro straining cannot constitute a complete treatment for effective disposal of algae, but it can be used as a part of treatment line. Moreover, this procedure requires frequent cleaning of strainer.

CHLORINE TREATMENT

Chlorine treatment is relatively cheap, readily available and provides prolonged disinfecting action. Though chlorine is generally used for disinfecting potable water it can also be used as an algaecide. Pre-chlorination has specific toxic effect and it causes death and disintegration of some of the algae. It also assists in removal of algae by coagulation and sedimentation. It prevents growth of algae on basin walls and destroys slime organisms on filter sand thus prolonging filter and facilitating filter washing.
Dosage*:* Effective chlorine dose should be such that sufficient chlorine is there to react with organic matter, ammonia, iron, manganese and other reducing substances in water and at the same time leave sufficient chlorine to act as algaecide. Dose required for this purpose may be over 5mg/l. With chlorine treatment essential oils present in algae as well as organic matter of dead algae are liberated this may lead to development of odour and color and taste. In such cases break point - chlorination is required. Post chlorination dose can be adjusted to obtain minimum 0.2mg/ L residual chlorine in potable water at consumer end.

Method of Application: Chlorine is preferably applied as a strong solution of chlorine from chlorinator. Slurry of bleaching powder can also be used. For algal growth control, generally, chlorine is administered at the entry of raw water before coagulant feeder.

7.2 Iron Removal Plants

Two types of such plants are described below:

Compact type plant

The process comprises of:

- Spray aeration through a grid of pipes to flush out CO2, H2S and to improve pH level.
- Trickling of aerated water through a contact catalytic media viz., limestone of 20 mm size or a combination of MnO2 (Manganese dioxide) and lime; or hard coke, MnO2and limestone.
- Sedimentation.
- Filtration through Rapid Gravity Filter.
- Disinfection.

The structure consists of ordinary masonry or concrete. The aerator with contact media maybe placed at the top of the sedimentation tank. Sedimentation tank may be rectangular with a length to breadth ratio of 3:1. The detention time may be around 3-5 hours. The surface loading may be around 25 m3/day / m². Filter media shall consist of sand with effective size0.5-0.7 mm and a depth of 750-1000 mm over a 450-600 mm deep gravel 3 to 50 mm size.

Operation and Maintenance

1. The nozzles/orifices attached to the aeration pipe grid shall have their angles so adjusted as to ensure maximum aeration and to prevent loss of water. These nozzles/orifices shall require regular manual cleaning to remove incrusted iron. The

residual iron deposits from inside the pipe grid shall be flushed out by opening end plugs or flanges. These operations should be repeated at least once in 2 months.

2. The limestone and other contact media require manual cleaning and washing at least once in 45-60 days.
3. The contact media bed should not remain exposed to sun for a long time to prevent hardening of bed by iron incrustation.
4. The sedimentation tank inlet baffle wall opening shall be cleaned of iron slime at least once in 45-60 days.
5. Sedimentation tank bed should be regularly scoured for removal of sludge.
6. Floc forming aid (coagulant aid) may be used for better coalescing and agglomeration.
7. The rapid gravity filter should have a water depth of about 1.2-1.5 m.
8. Since iron deposits create incrustation of filtering media, at least 100-150 mm of tops and layer of sand shall be scrapped and replenished with fresh sand at least once on 60 days. The whole bed may require replacement once in 2 years or so.
9. The characteristics of iron flocs are different from those of surface (river) water flocs. Due to the aeration process and contact of water with air, there may be incrustation of filter bed by residual oxidized deposits. To avoid this, common salt may be mixed with standing water and after 1-2 hours, the filter may be backwashed for better results and longevity of sand bed.

Package Type IRP (Iron removal plant)

The process incorporates the following steps:

1) Dosing of sodium aluminates solution to the raw water pumping line, to raise pH up to the optimum level and to ensure subsequent coagulation, as it is an alkaline salt.
2) Injection of compressed air for oxidation of dissolved iron.
3) Thorough mixing of raw water, sodium aluminates and compressed air for proper dispersion in a mixing chamber of M.S. welded cylindrical shell equipped with one M.S perforated plate fitted inside through which the mixture flows upward.
4) Passing the mixture through an oxidation chamber of M.S. shell, in which a catalytically media of MnO2 (Manganese dioxide) is sandwiched between two M.S. perforated circular plates. (Through which the mixture flows).
5) Passing the above mixture in to a M.S. welded cylindrical shell type of filter in which dual media comprising of Anthracite Coal or high graded bituminous coal, 3-6 mm size, is placed at the top and finer sand of 0.5-1.00 mm size with 98% silica content is placed at the bottom, over a gravel supported bed. At the bottom is the under drainage system. Backwashing is done by air agitation followed by backwash with water.
6) Disinfection.

Operation and Maintenance

1) Sodium aluminate should be so mixed as to raise the pH up to 8.5-9.5.
2) The quantity of compressed air should be so regulated as to achieve the optimum oxygen level.
3) The MnO2 (Manganese dioxide) may need replacement every 6-9 months.
4) The inside of both the mixing chamber and oxidizing chamber should be coated with epoxy resin to avoid corrosion and incursion.
5) The filtration rate should be controlled within a range of 100-125 lpm /m2.
6) The inlet pipe at the top should be fitted with a cylindrical strainer to obviate the possibility of loss of anthracite coal during washing.
7) After backwashing, rinsing of filtering media for at least 5 minutes has to be done to resettle the filtering media before normal functioning.
8) Where the iron content is very high the whole media like MnO2 (Manganese dioxide), anthracite coal, sand, gravel, strainers etc. require replacement and replenishment at

least once a year for effective functioning and performance. The interior epoxy painting should also be done simultaneously.

Resources for O&M of Iron Removal Plant

1) Unskilled labour required for re-sanding. Semi-skilled labour (caretakers) is required for plant operation. Skilled labour (supervising manger) is required for supervision.
2) Materials and equipment include sand, basic tools, valve replacement and spares, flow indicator, turbidity apparatus, bacteriological testing equipment.
3) Finances would typically be from the household paying water charges, GP/VWSC resources and Government funds.
4) The most widely used IRP in the rural area for removing excess iron from drinking water source is based on oxidation, sedimentation and filtration.
5) Specific Treatment Technologies

7.3 Arsenic& Fluoride removal methods

There are several treatment methods available for the removal of arsenic in waters for potable use. They include: -

1) Chemical precipitation
2) Adsorption
3) Membrane processes

7.4 Brackishness Removal Plant

Membrane based desalination plants popularly known as Reverse Osmosis (RO) plants.

Based on the above process each of the manufacturers has designed the treatment units with variable components and design parameters. It is important that O&M manual is obtained from the manufacturer and a guide booklet for field level operators prepared with simple language for their easy understanding. In all such treatment plants the telephone number of the operator should be painted on the building/machinery for contacting them during breakdowns.

(Refer CPHEEO O&M Manual p75-77

CHAPTER -8

DISINFECTION OF WATER

Drinking water is disinfected to kill bacteria, viruses and parasites, which may exist in the water and may cause illness and disease like ***Campylobacter, cholera, amoebic dysentery, Giardia*** (beaver fever) and ***Cryptosporidium***. These organisms usually get into drinking water supplies when source of waters such as lakes or streams, community water transmission pipes or storage reservoirs are contaminated by animal waste or human sewage. Generally deep wells are safer than shallow wells if chemical contamination is absent. In fact, shallow dug wells are often as contaminated as lakes or streams.

The disinfection of potable water is almost universally accomplished by the use of gaseous chlorine or chlorine compounds. Chlorine is easy to apply, measure and control. It persists reasonably well and it is relatively inexpensive. Other methods of disinfection are also available viz. ozone, ultra-violet light, chlorine dioxide, silver ionization etc.

8.1. Chlorination

The primary objectives of the chlorination process are disinfection, taste and odour control in the system, preventing the growth of algae and other micro-organisms that might interfere with coagulation and flocculation, keeping filter media free of slime growths and mud balls and preventing possible built up of anaerobic bacteria in the filter media, destroying hydrogen-sulphide and controlling sulphurous taste and odour in the finished water, removing iron and manganese, bleaching of organic colour.

Dosage: Effective chlorine dose should be such that sufficient chlorine is there to react with organic matter, ammonia, iron, manganese and other reducing substances in water and at the same time leave sufficient chlorine to act as algaecide. Dose required for this purpose may be over 2mg/L Post chlorination dose can be adjusted to obtain minimum 0.2to 0.5 mg/l residual chlorine in potable water at consumer end
Methods: Disinfection is carried out by applying chlorine or chlorine compounds. The methods ofapplication are as follows:

1. Preparing weak solution by bleaching powder,
2. Preparing weak solution by electrolysing brine solution.
3. By adding chlorine either in the form of gas or solution prepared from dissolving chlorine gas in small feed of water.

(a) Disinfection by Bleaching Powder

Bleaching powder or calcium hypochlorite is a chlorinated lime, which contains about 25 to34% of available chlorine by weight. Chlorine being a gas is unstable and as such it is mixed with lime to retain its strength for a longer period, as far as possible. The bleaching powder is hygroscopic in nature. It loses its chlorine strength rapidly due to poor storage and hence should not be stored for more than three months. The method of chlorination by bleaching powder is known as hypo-chlorination. The combined action of hypochlorous acid and hypochlorite ion brings about the disinfection of water.

Preparation of Solution

1) The concentrated solution of bleaching powder is prepared in one or two tanks of *capacity* suitable for 24 hours requirement.

2) The tank inside should be of glazed tiles or stoneware and should be covered.
3) The powder is first put on a perforated slab placed longitudinally inside the tank at a higher level, with respect to bed level of tank.
4) Water is sprinkled on the powder through a perforated pipe above this perforated slab.
5) The solution of bleaching powder & water now enters the tank. The solution is rotated for thorough mixing of powder with water by a hand driven/motor-reduction gear operated slow speed stirrer is now ready for use as disinfectant.
6) The precipitates of calcium hydroxide settle at the bottom of the tank. The supernatant water, which contains OCl, Cl- plays the important role in disinfection.
7) For effectiveness of chlorination, contact period of at least 4 hours shall be maintained

Dosing of Solution

The solution is discharged to a small measuring tank at a lower level through PVC pipe or any other material resistant to chlorine. The level of water in this tank is maintained constant through a float valve. A micrometer orifice valve discharges the solution at any pre-set rate, by adjustment on the scale fitted on it. The solution is dosed to the clear water channel by gravity at the time of entry to clear water reservoir. The dose has to be monitored properly, depending on the desired residual chlorine required in clear water reservoir. The waste precipitates at the bottom of tanks are taken out occasionally by scour valve.

Precautions

1. The operating personnel should use hand gloves, aprons and other protective apparel, while handling and mixing.
2. The valves, stirrer, tanks, plumbing arrangements require renovation at every 6 months or so.

(b) Chlorination by Gaseous Chlorine

Elemental chlorine at a normal pressure is a toxic, yellow green gas, and is liquid at high pressure. Chlorine gas is released from a liquid chlorine cylinder by a pressure reducing and flow control valve operating at a pressure less than atmospheric pressure. The gas is injected in the water supply pipe where highly pressurized water is passed through a venture creating a vacuum that draws the chlorine in to the water stream. Adequate mixing and contact time must be provided after injection to ensure complete disinfection of pathogens. It may be necessary to control the PH of water. A basic system consists of chlorine cylinder mounted with vacuum regulator, chlorine gas injectors, and a contact tank or pipe. Prudence or state regulation would require that a second cylinder and gas regulator be provided with a change-over valve to ensure continuity of disinfection. Additional safety and control system may be required.

Chlorine is very effective for removing almost all pathogen and is appropriate for both a primary and secondary disinfectant. The limitation with this is, it is dangerous gas that is lethal at concentrations as low as 0.1 per cent air by volume.

8.2 Electro-chlorinator

Chlorine is instantly produced by electrolyzing brine solution. Common salt is mixed with water to prepare brine solution. This solution is passed through an Electrolyser of electrodes comprising of anodes & cathodes, which are energised by D.C. current to produce NaOCl. This solution of sodium hypo chlorite is used as disinfectant.

The electro chlorinator set basically comprises of two compartments one comprising of Brine solution tank, electrolyser, cooler, etc. and the other comprising of compact panel board (rectifier). Normal life of electro chlorinator is 12 years provided reconditioning of the electrodes at regular interval of four years is carried out. These chlorinators are available at various capacities ranging from 50 gm. /hr. to 18 kg/h of active chlorine production.

The electrolyser consists of a number of electrodes as required. For 500 gm. /hr. capacity plant, there are 6 nos. of electrodes comprising of anodes and cathodes. The rectifier is having facilities for auto tripping if there is variation in certain set conditions.

Operation of Electro-chlorinator

For starting the operation, open the brine solution diaphragm valve for a flow to electrolyser. Flow meter No.1, for fresh water is now opened, so that dilution starts inside the electrolyser. The pressure of incoming fresh water should be 1 to 1.1 kg/ cm2 As soon as the outflow from surge tank starts, electrical operation through rectifier is to be started.

Before starting rectifier, A.C MCB is to be put in 'ON' position. A.C. mains supply in3 phases is to be checked through indicator lamps. A.C. voltage reading is checked so that requisite voltage of 355 V to 455 V comes to rectifier. By rotating potentiometer clockwise, the D.C. volt and D.C. ampere are set to 23-25 V & 95-100 Amps, respectively. Now electrolysis process is started.

1. Before closing the operation, brine solution diaphragm valve is to be closed and freshwater is to be allowed inside the electrolyser for cleaning of electrodes for 15-20 minutes.Simultaneously, potentiometer is to be operated in anticlockwise direction slowly to set to "zero" position. Now AC main MCB is put to "OFF" position.
2. If there is any sudden power trip, potentiometer is to be set to 'Zero' position to avoid any sudden shock to the whole system, if power comes back again, immediately. In that case, brine solution diaphragm valve is also to be closed & only fresh water is allowed through flow meter No.1 for 10-15 minutes.
3. If the temperature of hypo solution is increased (i.e. more than ambient temperature+ 12C), it is sensed through sensor & there will be auto tripping. Potentiometer is then brought to zero position. Then brine solution is closed & fresh water is circulated through flow meter No.1 for 20 to 25 minutes, before re-starting. The cooler is checked conveniently to see its effectiveness.
4. Before closing down of the electro chlorination the flow meter No.1 will be operated for 15 to 20 minutes for cleaning the electrodes. If the brine solution concentration is reduced, then the D.C volt will rise from 23 to25 V & there will be corresponding fall of ampere reading from 95 to100 A. At that time, the concentration is to be restored by adding salt & water.
5. Normally 4.5 kg. of common salt (NaCl) is required to produce 1 Kg. of chlorine with4.5 kWh power.

Maintenance of Electro-chlorinator

1. If there is deposition of chemicals on the body of the electrodes, then D.C. voltmeter will indicate high voltage & concentration of hypochlorite solution will reduce, which can be detected on checking chlorine content. In such a situation electrodes are to be cleared.
2. If there is any fault, all fuses, contact points & their joints are to be checked.
3. D.C. voltage must be kept within the range of 23 volt to 25 volt. The rectifier shall be cleaned and checked occasionally so that all electrical connections remain intact.
4. Plumbing arrangements shall also be cleaned from time to time, to check the salt deposition.
5. Due to accumulation of positive and negative ions on the anodes and cathodes of the

electrolyser, the efficiency of electrolyser process gets reduced and as such the electrodes require cleaning every 25 to 30 days with water jet i.e. without touching them by hands.

6. The staff will require special training for routine maintenance and annual maintenance contract to the specialised agency could be considered for trouble free maintenance of the system.

8.3 Other Disinfectant

The other chemical based disinfectants generally in used are ionized silver coating, gaseous chlorine, ozone, Chloramine, potassium permanganate and hydrogen peroxide. A number of commercially available alternative processes, such as membrane processes, are able to remove bacteria, viruses and protozoa as well as a range of chemical contaminants. These are coming into use but generally only on a small scale. It may be possible to operate these processes with no chemical disinfection or at least to reduce the amount of chemicals used for final disinfection. Alternatives to chemical disinfection, such as UV irradiation, are also being used for disinfection of drinking water. Such 'non-conventional' processes and disinfection methods could in principle be used to replace, or at least greatly reduce, the use of chemical disinfection of drinking water.

a)Ultra Violet Disinfection

UV irradiation and membrane processes are potentially suitable alternatives to chemical disinfection. UV is capable of inactivating bacteria and viruses, and possibly protozoan parasites. A range of pressure-driven membrane processes – microfiltration, ultra-filtration, Nano-filtration and reverse osmosis in order of decreasing pore size – are also capable of disinfection as well as removal of chemical contaminants, depending on pore size. The use of membrane processes would avoid the formation of disinfection by-products and would reduce the concentrations of other undesirable chemicals, giving a net benefit in terms of toxicological issues. The main microbiological concerns with membrane systems are ensuring the integrity of the membrane and monitoring the efficiency of micro-organism removal; with conventional chlorination the residual chlorine concentration is easily monitored and provides reassurance that disinfection has been carried out effectively.

b) Ozonation

Ozone is very strong oxidiser and powerful disinfecting property .Avery small concentration of ozone in water makes it free from bacteria, virus and pathogen much faster and with lesser concentration in a most effective manner.

Ozone, an allotrope of oxygen having three atoms to each molecule, is a powerful oxidizing and disinfecting agent. It is formed by passing dry air through a system of high voltage electrodes.

The major elements of an ozonisation system are:

1) Air preparation of oxygen feed
2) Electrical power supply
3) Ozone generation –usually using a corona discharge cell consisting of two electrodes
4) Ozone context chamber, and
5) Ozone exhausts gas destruction.

Advantages of Ozonation system-It requires shorter contact time and doses than chlorine, ozone does not directly produce halogenated organic materials unless a bromide ion is present.

Limitations of Ozonation system- Ozone gas is unstable and must be generated onsite. A secondary disinfectant, usually chlorine, is required because ozone does not maintain an adequate residual in water.

c)Chloramine

Chloramines are formed when water containing ammonia is chlorinated or when ammonia is added to water containing chlorine (hypochlorite or hypochlorous acid)

Chlorine (gaseous solution or as sodium hypochlorite) is injected in to the supply main followed immediately by injection of ammonia (gaseous solution or as ammonium hydroxide), with adequate mixing and contact time, the mix of products produced when water, chlorine, and ammonia are combined in ratio of 5:1 with PH value more than 5. If the PH drops below 5, some nitrogen tri-chloride may be formed.

Chemicals used to generate chloramine from ammonia and chlorine gas depend upon the ammonia based chemical used. Anhydrous ammonia is the least expensive, while ammonium sulphate is the most expensive.

An advantage of chloramineis, an effective bactericide that produces fewer disinfection by-products, chloramine is generated onsite. Usually, chloramine forming reactions are 99% complete within a few minutes. Limitation of chloramine is, it is a weak disinfectant .It is much less effective against viruses or protozoa than free chlorine. Chloramine is appropriate for use as secondary disinfectant to prevent bacteria regrowth in a distribution system.

8.4 Emergency Measures

The water agency/VWSC must arrange and ensure supply of safe water during all emergency situations. However, the disinfection of water by boiling or using more chlorine dosages or chlorine tablets shall be practiced by community on advisory issued by water agency/VWSC in following situations as temporary measures:

- using water directly from a stream, lake or shallow well;
- Lab tests of water show that it contains "fecal coli forms";
- A flood, earthquake or other disaster has disrupted community water supply;
- travelling in an area where water is not well treated; or
- There is a weakened immune system, in which case disinfect all of your drinking water.

These methods are described in details the CPHEEO manual (1999 and O&M manual (2005) chapter 6.

CHAPTER –9
STORAGE OF WATER
(Reservoirs including service reservoirs)

The main function of Reservoirs and Service Reservoirs (SR) is to cater for daily demands and especially peak demands of water. Operator checks the amount of water in the storage reservoir and the corresponding water levels at particular times of the day. Procedures for operating the Service Reservoir will depend upon the design of its storage capacity and on the water demand.

9.1 Procedures for Operation of Service Reservoir (S.R.)

Service Reservoirs have to be operated as per the design requirements. Generally, the service reservoirs are constructed at elevated place to supply water during periods of high water demand and hence the SRs are filled in low water demand period. At times pumps may be used only for filling the SR before the next supply timing or can be used also during supply hours to maintain the levels in the SR.

Normally, small changes in the distribution system such as pipeline extensions or the addition of few more connections will not require additional storage requirement. Major system changes such as addition of larger size of main pipelines and increase in large number of connections may require additional storage.

9.1.1 Operation of SRs during Abnormal Conditions

Abnormal operating conditions arise:

- Whenever demand for water goes up suddenly due to fire demand, or due to excessive demand on one command area/zone of a system.
- Due to failure or breakdown of water supply of another zone of the distribution system.
- Breakdown or out of service pumps or pipelines or power breakdowns or out of service SRs.

The operator must have a thorough knowledge of the distribution system emanating from the SRs. Closure or adjustment of valves at strategic points in the distribution system can focus or divert the flow of water towards the affected areas. Emergency plans must be developed in advance to cope with such situations.

9.1.2 Storage Level & Capacity

Most of the distribution systems establish a pattern of levels for assuring the required supplies at the required pressures. The maximum water levels to be maintained in the SR at each morning should be known to ensure that the system demands are met for the day. It is also desirable to have an indication of levels of SR in the pump house. Usually water levels are read at the same time each day and the readings recorded. Checks of water levels at other times of the day will enable to determine if any unusual consumption conditions have occurred. If any significant increase in consumption is anticipated the operations should ensure a corresponding increase in supply into the SR.

In case of intermittent supply, timings for supply of water in the areas are fixed in advance in large command areas. The water can be supplied to sub-zones during particular fixed hours by operation of the necessary valves. Routine valve operations are normally done at the SRs. Problems in operation of valves in SRs can also be caused by valve seat getting jammed, and hence cannot be opened, or non-seating of valves, and hence cannot be closed properly. Sometimes two valves are fixed in series on the outlet and the downstream valve only is usually operated. Whenever the valve under operation is jammed the upstream valve is closed and the jammed valve is repaired. Such an arrangement enables repair of valves without emptying the SR. In some SRs a bypass line is provided direct from the inlet line to the outlet line for drawing water without feeding the SR. Identification of the valves as to their intended purpose such as inlet, outlet, scour, bye-pass etc. and their direction of opening are to be prominently marked. The operator/manager shall ensure that all valves in a SR are in good working condition and are operated as per the schedule for such operation

9.1.3 Water Quality at SR

Water from all SRs should be periodically sampled to determine the quality of water that enters and leaves the SR. Sampling data can help in setting up periodic cleaning of SR. Common cause of physical water quality problems includes collection of sediment, rust and chemical precipitates. Water quality in a SR may also deteriorate due to excessively long periods of stagnant conditions. Whenever seasonal demand rises, residual chlorine to be maintained properly.

9.2 Plans for O&M of Service Reservoir

The plan for O&M of the service reservoirs shall contain operational procedures, maintenance procedures and the manufacturer's information in respect of the instruments/gauges.

9.2.1 Procedures for Operations

The operational procedures inter-alia will contain:

- Information of design details for the reservoir such as: capacity in liters, size and depth of storage; size of piping/locations of control valves of inlet, outlet, scour and overflow; source of feeding the reservoir; hours of pumping or gravity feeding into the reservoir; rate of flow into the reservoir; hours of supply from the reservoir and quantity to be supplied from the reservoir; areas to be served/ supplied; highest and lowest elevations to be commanded from the SR and the water levels to be maintained in the SR for command of the entire area.
- Key plan showing the alignment of pipe connections, by pass lines, interconnections and location of valves, flow meters, pressure gauges and alignment of out-fall drain to lead off the scour and overflow water from the reservoir.
- Schedule of suppliers' names, addresses and telephone numbers of the equipment installed in the SR such as valves, flow meters, level indicators etc.
- Step by step operating instructions indicating how to operate and control various valves located on the inlets and outlets, so as to ensure the required quantity of water is supplied to the command areas at the desired pressures during the period required to be displayed.
- A record sheet for each valve showing direction for turning, number of turns, inspections, repairs and whether opens or closed. The direction of operation of valves shall be clearly marked as "open" or "close".
- The name of the valve and piping such as washout, inlet, outlet, by pass, overflow etc. shall be painted clearly and repainted regularly. In the case of mechanized operation of valves, the steps to include starting, running and stopping the operations.
- Different inlet pipes in the service reservoir from different source should be marked with different color paint

9.2.2 Maintenance of Service Reservoirs

- **Service Reservoirs** (SRs) have to be inspected regularly and the line department can prescribe frequency of inspections.
- Leakage from structure of SR and through the pipes and valves has to be attended to on priority. It is advisable to resort to pressure grouting to arrest leaks from structures and

sometimes an additional coating of cement mortar plastering is also done using water proof compound to arrest leaks from the structure

- Maintenance is concerned with mainly protection against corrosion both externally and internally. Corrosion of roof slab of RCC reservoirs due to the effect of chlorine is also common. Internal corrosion is prevented by cleaning and painting at regular intervals. Quite Toxic paints should not be used for painting interior surface of SRs. food grade epoxy painted shall only be used for internal surface of SRs. Anticorrosive painting (epoxy) is also done to the interiors when corrosion due to chlorine is expected. Painting of steel tanks once in a year and external painting with waterproof cement paint for exteriors of RCC Tanks once in 5 years is usually done. The inside of painted SR shall be disinfected before putting into use for a period sufficient to give chlorine residuals of at least 0.2 mg/l. Manhole covers & vent pipes shall always be properly placed and maintained
- The maintenance procedures shall include step by step procedure for every piece of equipment in SRs such as pipes inside the tank (In-let, out-let, wash-out, over-flow) valves, specials and flow meters following the procedures as per the manufacturers' catalogues.

(a) Pipes (In-let, out-let, wash-out, over-flow) and specials

- All the pipe fittings should be leak proof, any leakage nearby reservoir may affect the safety of reservoir
- Overflow pipe should be connected with the distribution system after the sluice valve installed on delivery pipeline.
- Concrete platform as protection works shall be provided around the service reservoir, if not provided, so as to safeguard the reservoir foundation from any leakages/overflow of water

(b) Valves

All valves should be inspected regularly in specified frequency of inspection and following activities shall be undertaken.

- Lubrication is required to be done regularly
- Spindles that develop leaks should be repacked
- Rust and sediment in the valve is removed by shutting the disc hard in the seat, then opening about a quarter way and closing tightly several times; the increased velocity usually flushes the obstructions away
- Valve chambers of the SR also require maintenance to ensure that the interiors of chambers are not silted up and also ensure that the covers are in good condition and are in position.
- Sluice valve chamber shall not be water logged

(c) CLEANING OF RESERVOIRS

Routine inspection is the best way to determine when a tank requires maintenance and cleaning. A visual inspection can be made from the roof manhole with water level lowered to about half full or less. Alternatively a detailed inspection can be made after draining the tank and then cleaning or washing. Best time of the year to take up cleaning of SRs is during the period of lowest water consumption.

The following activities are normally involved in cleaning of a tank/SR:

- Make alternate arrangement for water supply to consumers served by the SR.
- Close the inlet line before commencing cleaning of SR.
- Do not empty S.R. and always keep minimum water level at 200-300 mm in the SR.
- Close the outlet valve so that no water will be used while the tank is being cleaned.
- Drain and dispose of the remaining water and silt.
- Wash the interior of tank walls and floor with water hose and brushes.

- Inspect the interior of walls and ceiling of tank for signs of peeling off or deterioration.
- Apply disinfectant (Supernatant of Bleaching powder) to the walls and floor before start of filling the tank/SR.
- The higher frequency of cleaning of SR depends on the extent of silting, development of bio films and results from water quality monitoring. Generally cleaning of Service Reservoir may be periodically done.
- Date of last cleaning and the next due date of cleaning may be displayed on the outer surface of the S.Rs.

9.2.3 Records and Reports

9.3 Record System

A record system has to be developed which should be realistic and apply to the operating problems involved at the particular SR site. The most efficient way to keep records is to plan what data is essential and then prepare the formats followed by the persons to fill the data, frequency and to whom the record is to be sent for review and report. Sample records to be maintained at a SR site are given below for guidance.
The following details shall be recorded:

9.3.1 Records of Maintenance

The records on each of the following maintenance/repair works along with the cost of materials and labour shall be maintained along with date

- Water levels in the.
- Time and relevant operation of control valves with time of opening and closure or throttling position of the valves.
- Daily flow meter readings both on the inlets and outlets.
- At least one a day Residual chlorine readings of inflow water and outflow water.
- Gland ropes of the valves/Spares at the SR were changed.
- Manhole covers were changed/replaced.
- Water level indicator was repaired or replaced.
- Reservoir was cleaned.
- Out-fall drain for scour and overflow was last cleaned.
- Ladder was changed, when the structure of the reservoir was last repaired to attend to structural defects or arrest leakage.
- Reservoir/Pips was last painted
- Total cost of repairs and replacements at the SR in previous year along with breakup of material cost and labor cost with amount spent on outside agencies for repairs and replacements.

CHAPTER –10

DISTRIBUTION SYSTEM

The overall objective of a distribution system is to deliver safe drinking water to the consumer at adequate residual pressure in sufficient quantity at convenient points and achieve continuity and maximum coverage at affordable cost.

Normally, the operations are intended to maintain the required supply and pressure throughout the distribution system. Critical points are selected in a given distribution system for monitoring of pressures by installation of pressure recorders and gauges.

10.1 Issues Causing Problems in the Distribution System

(A) Intermittent System

The distribution system is usually designed as a continuous system but often operated as an intermittent system in rural areas. Intermittent supply creates doubts in the minds of the consumer's about the reliability of water supply. During the supply period the water is stored in all sorts of vessels for use in non-supply hours, which might contaminate the water. Often, when the supply is resumed, the stored water is wasted and fresh water again stored. During non-supply hours polluted water may enter the supply mains through leaking joints and pollute the supplies. Further, this practice prompts the consumers to always keep open the taps of both public stand posts and house connections leading to wastage of water whenever the supply is resumed. Intermittent systems and systems which require frequent valve operations are likely to affect equitable distribution of water mostly due to operator negligence.

(b) Non-Availability of Required Quantity of Water

Failure of source or failure of power supply may cause reduced supplies. Normally, the distribution affected reservoirs are designed for filling in about 8 hours of pumping and whenever the power supply is the pumping hours are reduced and hence the distribution reservoirs are not filled up leading to reduced supply hours and hence reduced quantity of water.

(c) Low Pressure at Supply Point

Normally peak demand is considered ranging from 2 to 3, whereas the water supply is given only for a different duration, leading to large peak factors and hence affecting the pressures in the distribution system. This is a common with most water supply systems.

(d)Leakage of Water

Large quantity of water is wasted through leaking pipes, joints, valves and fittings of the distribution systems either due to bad quality of materials used, poor workmanship, and corrosion, age of the installations or through vandalism. This leads to reduced supply, loss of pressure and deterioration in water quality.

Maintenance of appropriate positive pressure at all times to all consumers is the main concern of O&M. Negative pressure can cause contamination of water and very high pressure damages the pipelines. Low pressure may be avoided by taking the following steps.

- Purposefully or accidently a line valve is left closed or partly closed or blockage due to any material causing loss of pressure.
- Too high velocities in small pipelines
- Low water level in S.R.
- Failure of pumps/Booster pumps (either due to power failure or mechanical failure) feeding the system directly.

(e) Unauthorized Connections

Illegally connected users will contribute to the reduction in service level to authorized users/ consumers and deterioration of quality of water. Sometimes, even legally connected users draw water by sucking through motors causing reduction in pressures.

(f) Extension of Service Area

Due to extension of service area without corresponding extension of distribution mains, the length of house connections will be too long leading to reduction in pressures.

(g) Age of the System

With age there is considerable reduction in carrying capacity of the pipelines due to incrustation, particularly unlined CI, MS and GI pipes. In most of the places the consumer pipes get corroded and leaks occur resulting in loss of water reduced pressure and pollution of supplies

(h) Lack of Records

Records of replacement of fittings/pipes/valves, scouring of entire distribution system, system maps, designs of the network and reservoirs and historic records of the equipment installed in the distribution system are often not available, whereas some minimum information is required to operate and maintain the system efficiently.

10.2 Operational Schedule

10.2.1 Mapping and Inventory of Pipes and Fittings in the Water Supply System

Availability of updated distribution system maps with contours, location of valves, flow meters and pressure gauges or taping points is the first requirement for preparation of operation schedule. The agency should set up routine procedures for preparing and updating the maps and inventory of pipes, valves and consumer connections. The maps shall be exchanged with other public utilities to contain information on other utility services like electricity, communications etc.

10.2.2 Field Survey

Existing maps are used or conventional survey is employed for preparation and up-dating of maps. As an alternative to traditional survey and map preparation, 'total station method is gaining popularity. Total station instruments can be used for survey and mapping of villages where data is not readily available.

10.2.3 Routine Operations of the Water Supply Distribution System

The efficiency and effectiveness of a water supply system depends on the operating personnel's knowledge of the variables that affect the continuity, reliability, and quantity of water supplied to consumers. The operational staff should be able to carry out changes in the hydraulic status of the system as required depending on those variables promptly and effectively. Routine operations shall be specified which are activities for adjusting the valves and operation of contain procedures for operating the distribution system. It should contain procedures to obtain, process, and analyze the variables related to water flows, pressures and levels as well as the consequences of manipulating control devices, such as operation of valves and or pumps so that the hydraulic status of the system can match the demand for water. When operators change their shifts information on valve closure and opening must be exchanged.

10.2.4 Operations in Break Downs and Emergencies

Operations other than routine viz. during breakdowns and emergencies have to be specified and should be carried out in specific circumstances when normal conditions change i.e. when flows, pressures and levels and operation of pumps change

10.2.5 Measurement of Flows, Pressures and Levels

It will be necessary to monitor regularly operational data concerning flows, pressures and levels to assess whether the system is functioning as per requirements. Analysis of data may reveal over drawl of water to some reservoirs and or bulk consumers. At such places appropriate flow control devices may be introduced to limit the supplies to the required quantity. A list of priority points in water supply system have to be identified such as installation of meters to measure flows, pressures and levels. A detailed map showing location or each measuring point has also to be prepared. The degree of sophistication of the devices used at each measuring point with regard to indication, integration, recording, transmission and reception of data depends mainly on the skills of the O&M personnel available with the agency and affordability of the agency.

10.2.6 Sampling for Quality of Water

The agency operating the water supply system is charged with the primary responsibility of ensuring that the water supplied to the consumer is of an appropriate quality. To achieve this objective it is necessary that the physical, chemical and bacteriological tests are carried out at frequent intervals. Samples should be taken at different points on each occasion to enable overall assessment. In the event of epidemic or danger of pollution more frequent sampling may be required, especially for bacteriological quality. For each distribution system a monitoring programme has to be prepared showing the location of sampling points. Based on historic records of a system it will be possible for the manager of the system to decide locations for bacteriological sampling and residual chlorine testing.

10.3 Management in Times of Water Shortage

The objective of developing a programme for managing in times of shortage of water is to reduce the excessive use of water particularly when the source is limited due to adverse seasonal conditions. Basically it involves that a water conservation policy is developed and implemented among water consumers. The following activities can be considered while formulating such a water management project:

- Installation of accurate water meters and establishment of a realistic tariff structure to encourage water conservation and prevent wastage of water.
- Introduction of restrictions on use of flushing, showers and other household fittings.
- Introduction of devices to limit water consumption in flushing of toilets.
- Enforcement of restrictions on use of treated water for watering lawns, cooling, construction, washing of vehicles etc.
- Encouragement and/or enforcement of the reuse of treated industrial effluents and wastewater.
- Development and implementation of public education programmes to encourage water conservation.

10.4 System Surveillance

- Surveillance of distribution system is done to detect and correct.
- Sanitary hazards.
- Deterioration of distribution system facilities, [to detect].
- Encroachment of distribution system facilities by other utilities such as sewer and storm water lines, power cables, telecom cables etc. and
- Damages of the system facilities by vandalism. [Detecting and correcting].

10.5 Maintenance Schedule

- A maintenance schedule is required to be prepared to improve the level of maintenance of water distribution networks and house connections through improved co-ordination and planning of administrative and field work and through the use of adequate techniques, equipment and materials for field maintenance.

- The schedule has to be flexible so that it can achieve team action with the available vehicles and tools.
- Co-ordination of activities is required for spares and fittings, quality control of materials used and services rendered.
- Training of maintenance staff shall include training to achieve better public relations with consumers apart from the technical skills.

10.6 Activities in Maintenance Schedule

Following activities are to be included in the schedule:

- Establishment of procedures for setting up maintenance schedules and obtaining and processing the information provided by the public and the maintenance teams.
- Formation of maintenance teams for each type of service with provision for continuous training.
- Establishment of repair procedures for standard services.
- Specification of appropriate tools.
- Allocation of suitable transport, tools and equipment to each team.
- Establishment of time, labour and material requirement and output expected; time required and other standards for each maintenance task, and
- Monitoring the productivity of each team.

10.7 Preventive Maintenance Schedule

A preventive maintenance schedule for Servicing of Valves and Maintenance of Valve Chambers, Maintenance of the pipelines: may include the tasks, set priorities, issue of work orders for tasks to be performed, list of scheduled tasks not completed, record of when the tasks are completed and maintaining a record of tools, materials, labour and costs required. to complete each task.

10.8 Leakage Control

Wastage of water in the system and distribution network occurs by way of leakage from pipes, joints & fittings, reservoirs and overflow from reservoirs & sumps. The objective of leakage control programme is to reduce the wastage to a minimum and minimize the time that elapses between the occurrence of a leak and its repair. The volume of water lost through each leak should be reduced by taking whatever action is technically and economically feasible to ensure that the leak is repaired as quickly as possible. To achieve this, the organization shall prescribe procedures for identifying, reporting, repairing and accounting for all visible leaks. It will be beneficial for the agency if the procedures involve the conscious and active participation of the population served by the agency apart from its own staff. The Management has to process the data and evaluate the work on detection and location of leaks and for dissemination of the results and initiate actions to control the overall problem of water loss. Interim measures for reduction/control of leakage can be initiated by controlling pressures in the water distribution system where feasible.

10.8.1 Leakage through House Connections

Leakage can be controlled at the point of house connection and in the consumer pipe by adopting correct plumbing practices and improving the methods used for tapping the main and giving house connection and strict quality control on the pipe material used for house connection. An analysis of leaks in house connections and investigation of reasons for leaks in the house connections shall be carried out to initiate action on reducing the leakage through house connections.

10.8.2 Procedures for reporting Visible Leaks

The water agency has to establish procedures whereby the population served by the agency can notifies the visible leaks. The agency staff can also report visible leaks found by them while carrying out other works on the water supply system. Water supply agency has to establish procedures for prompt repair of leaks and for attending efficiently and accurately to the leaks.

Critical areas where leaks often occur have to be identified and appropriate corrective measures have tube implemented.

10.8.3 Procedures for Detecting Invisible Leaks

Establishment of procedures for detecting and locating non-visible leaks shall be compatible with the technological, operational and financial capability of the agency. Selection and procurement of equipment for detection and location of leaks must take into account the cost-effectiveness and the financial capability of the organization.

10.9 Cross Connections

Contaminated water through cross connections of water supply lines with sewers and drains is a problem prevailing widely. Intermittent supply further aggravates the problem since, during non-supply hours polluted water may reach the supply mains through leaking joints, thus polluting the supplies. In certain instances, when there are extremely high water demands, the pressures in the supply mains are likely to fall below atmospheric pressure, particularly when consumers start use of pumps with direct suction from supply mains. Regular survey has to be undertaken to identify potential areas likely to be affected by cross connections and back-flow. All field personnel should be constantly alert for situations where cross connections are likely to exist. After identifying the cross connections, remedial measures are taken up which include: providing horizontal and vertical separation between the water main and the sewer/drain, (refer to Para 10.11.1 of Chapter 10 of Manual on “Water Supply & Treatment”), providing a sleeve pipe to the consumer pipes crossing a drain, modifying the piping including changing corroded piping with non-corrodible piping, providing double check/non return valves at the consumer end etc.

The various types of material of pipe &specials are being used in distribution system, namely CI,GI, DI,MS,PVC, HDPE, GRP RCC, AC, etc. and specific requirement of maintenance are to be followed as per the CPHEEO Manual/ Manufacturer’s recommendations.

10.10 Plumbing Practices for Drinking Water Supply

The internal plumbing system of the consumer shall conform to the National Building Code and also particularly to the bye laws of concerned water utility/local authority. The various types of plumbing materials are being used, namely GI MDPE & PVC, etc. and require different maintenance practices. Hence specific requirement of maintenance are to be followed as per the CPHEEO Manual/ Manufacturer’s recommendations

10.10.1 Quality of Pipe Material for House Connection

The water agency/VWSC shall ensure that the connection and communication pipe from the street main up to the consumer premises is laid as per correct plumbing practices and adopt improved methods for tapping the main. Strict quality control is required on the pipe material used for house connection. The bye Laws shall lay down rules for defining the ownership and responsibility for maintaining the point of connection and the communication pipe. In several utilities the communication pipes are leaking since they are corroded; however these are not replaced by the consumer or by the utility particularly where the O&M responsibility for consumer pipe rests with the consumers.

10.10.2 Contamination through House Connection

While laying the consumer connection pipes there are a need to avoid contamination of water supplies. This can be achieved by maintaining horizontal and vertical separation between the water supply communication pipe and the sewer/drain. In some instances a sleeve pipe may be required to be provided to the consumer pipes crossing a drain. It is always recommended to provide a non-corrodible pipe material for the consumer connection. Contamination by possible back flow can also be prevented by ensuring provision of double check/non-return valves at the consumer end.

10.10.3 Rules for Consumer Connections

The water agency/ VWSC shall formulate rules for sanction of consumer connection, tapping the mains and laying the connection piping. Water utility shall undertake inspection of the consumer premises before releasing the connection to ensure that the internal plumbing system of the consumer conforms to the National Building Code. Water agency/VWSC shall supervise the process of drilling/tapping of the main for giving connection and laying of the consumer piping. The process of submission of applications for connections by consumers and carrying out the connection work through licensed plumbers is also prevalent in some utilities. In such cases the agency/VWSC shall formulate procedures for licensing the plumbers including the qualifications to be possessed by the plumber, facilities and tools to be available with the plumber for the work to be undertaken by the plumber. The agency/VWSC shall closely observe the quality of materials used and works done by him and he should act as per procedures laid down in the bye laws for approval of the connection works, renewal or cancellation of the plumbers' licenses or any other requirement depending on their performance or nonperformance.

10.11 Chlorine Residual Testing at Consumer End

A minimum chlorine residual of about 0.2 -0.5mg/l at the selected monitoring point/ consumer's end is often maintained to ensure that even a little contamination is destroyed by the chlorine. Hence, absence of residual chlorine could indicate potential presence of heavy contamination. If routine checks at a monitoring point are carried out, required chlorine residuals and any sudden absence of residual chlorine should alert the operating staff to take up prompt investigation. Immediate steps to be taken are:

- Re-testing for residual chlorine,
- Checking chlorination equipment,
- Searching for source of contamination, which has caused the increased chlorine demand, and
- Immediate stoppage of supplies from the contaminated pipelines.

10.12 Sample records to be maintained by the water agency/ VWSC are given below for guidance:

- Updated system map,
- Pressure and flow readings at selected monitoring points,
- Persistent low pressure or negative pressure areas,
- Age of pipes/quality of pipes,
- Pipelines to be replaced,
- Presence of undesirable materials,
- Water budget for each zone served by one SR,
- Number of connections given,
- Number of meters out of order
- Quantity measured at outlet of reservoir,
- Quantity distributed/measured or billed,
- Water budget for each zone served by one SR
- Source of leaks and persistent leak points,
- Status of bulk meters - functioning or not,
- Status of consumer meters,
- Facilities for repairs of consumer meters,
- Number of unauthorized connections,
- Residual chlorine levels at the pre-selected monitoring points,
- Bacteriological quality of the water sampling points,

- Persistent areas where residual chlorine is absent/where water samples are found contaminated ,
- Record of carrying out repairs on the following
- The pipe line leaks or replacement of pipes.
- Change of gland ropes of the valves in distribution system.
- Record on man hours spent on routine operations in the distribution system in the previous year and the cost thereof,

10.13 Record keeping.

- To maintain necessary inventory of the materials used and required. Record of total cost of repairs and replacements in previous years along with breakup of material and labor costs with amount spent on outside agencies for repairs and replacements,
- Replacement of damaged manhole covers.
- Record on when the exposed piping was last painted and the cost of materials and labor cost thereof, and
- Record on the un-served areas - extension of pipelines- need for interconnection.

CHAPTER –11

PUMPING MACHINERY

11.1 General

Pumping machinery and pumping station are very important components in water Supply system. Pumping machinery is subjected to wear, tear, erosion and corrosion due to their nature of functioning and therefore is vulnerable for failures. Generally more number of failures or interruptions in water supply is attributed to pumping machinery than any other component. Therefore, correct operation and timely maintenance and upkeep of pumping stations and pumping machinery are of vital importance to ensure uninterrupted water supply. Sudden failures can be avoided by timely inspection, follow up actions on observations of inspection and planned periodical maintenance. Downtime can be reduced by maintaining inventory of fast moving spare parts. Efficiency of pumping machinery reduces due to normal wear and tear. Timely action for restoration of efficiency can keep energy bill within reasonable optimum limit. In case there is no standby pump provision, suitable water pumps identical duty condition shall be provided 100% standby in case of single pump set, and two or more pumps with 50% standby along with all necessary accessories like cables, control panels, safety equipment, valves and fittings etc. Providing 50% standby pump set will help in operating the schemes in initial stage until stabilization is achieved.

In case of depletion of sources during summer/ monsoon failure, the schemes can be operated partially without throttling of pumps. While replacement of motors/ pumps is done, it may be insisted to provide star rated motors to have energy savings. Generally, as the pumps are scheme specific, (i.e. Discharge & head fixed depending upon the requirement) the question of standardization with regard to minimizing the inventory does not arise. To ensure better performance/ for effective cost savings energy audit and water audit need to be done for every scheme.
Annual monitoring of handed over schemes must be done by the department who executed the scheme. Proper record keeping is also very important.

A log book should be maintained covering the following items.

- Timings when the pumps are started, operated and stopped during 24 hours,
- Voltage in all three phases,
- Current drawn by each pump-motor set and total current drawn at the installation,
- Frequency,
- Readings of vacuum and pressure gauges,
- Motor winding temperature,
- Bearing temperature for pump and motor,
- Water level in intake/sump,
- Flow meter reading,
- Daily PF over 24 hours duration, and
- Any specific problem or event in the pumping installation or pumping system e.g. burst in pipeline, tripping or fault, power failure.

11.2 Components in Pumping Stations

The components in pumping station can be grouped as follows.

i) Pumping machinery

a) Pumps and other mechanical equipment, i.e. valves, pipe work, vacuum pumps
Motors, switchgears, cable, transformer and other electrical accessories

ii) Ancillary Equipment

a) Lifting equipment
b) Water hammer control device
c) Flow meter
d) Diesel generating set

iii) Pumping station

a) Sump/intake/well/tube well/bore well
b) Pump house
c) Screen
d) Penstock/gate

11.2.1 Type of Pumps

Following types of pumps are used in water supply systems:

- Centrifugal pumps
- Vertical turbine pumps
- Oil lubricated
- Self-water (pumped water) lubricated
- Clear water lubricated
- Submersible pumps
- Vertical bore well type pump-motor set
- Mono bloc open well type pump-motor set
- Jet pumps
- Reciprocating pumps

11.2.2 Important Points for Operation of the Pumps

Various types of pumps are in use and the specification of O&M schedule provided by manufacturers shall be followed. However, the following points shall be observed while operating the pumps:

a) Dry running of the pumps should be avoided.
b) Centrifugal pumps have to be primed before starting.
c) Pumps should be operated only within the recommended range on the head-discharge Characteristics of the pump.
   i. If pump is operated at point away from duty point, the pump efficiency normally reduces.
   ii. Operation near the shut off should be avoided, as the operation near the shut off causes substantial recirculation within the pump, resulting in overheating of water in the casing and consequently, overheating of the pump.
d) Voltage during operation of pump-motor set should be within + 10% of rated voltage. Similarly current should be below the rated current as per name plate on the motor.
e) Whether the delivery valve should be opened or closed at the time of starting should be decided by examining shape of the power-discharge characteristic of the pump. Pump of low and medium specific speeds draw lesser power at shut off head and power required increases from shut off to normal operating point. Hence in order to reduce starting load on motor, a pump of low or medium specific speed is started against closed delivery valve. Normally the pumps used in water supply schemes are of low and medium specific speeds. Hence, such pumps need to be started against closed delivery valve. The pumps of high specific speed draw more power at shut off. Such pumps should be started with the delivery valve open.

f) The delivery valve should be operated gradually to avoid sudden change in flow velocity which can cause water hammer pressures. It is also necessary to control opening of delivery valve during pipeline - filling period so that the head on the pump is within its operating range to avoid operation on low head and consequent overloading. This is particularly important during charging of the pumping main initially or after shutdown. As head increases the valve shall be gradually opened.

g) When the pumps are to be operated in parallel, the pumps should be started and stopped with a time lag between two pumps to restrict change of flow velocity to minimum and to restrict the dip in voltage in incoming feeder. The time lag should be adequate to allow stabilizing the head on the pump, as indicated by a pressure gauge.

h) When the pumps are to be operated in series, they should be started and stopped sequentially, but with minimum time lag. Any pump, next in sequence should be started immediately after the delivery valve of the previous pump is even partly opened. Due care should be taken to keep the air vent of the pump next in sequence open, before starting that pump.

i) The stuffing box should let a drip of leakage to ensure that no air is passing into the pump and that the packing is getting adequate water for cooling and lubrication. When the stuffing box is grease sealed, adequate refill of the grease should be maintained.

j) The running of the duty pumps and the standby should be scheduled so that no pump remains idle for long period and all pumps are in ready-to run condition. Similarly unequal running should be ensured so that all pumps do not wear equally and become due for overhaul simultaneously. If any undue vibration or noise is noticed, the pump should be stopped immediately and cause for vibration or noise be checked and rectified.

k) Bypass valves of all reflux valve, sluice valve and butterfly valve shall be kept in closed position during normal operation of the pumps.

l) Frequent starting and stopping should be avoided as each start causes overloading of motor, starter, contactor and contacts. Though overloading lasts for a few seconds, it reduces life of the equipment.

Additional Points for Operation of the Pumps

(a)Submersible pumps:

- Correct rotations
- Pump is below static water level before starting, and continues to be below draw down level throughout the operation.

(b)Centrifugal pumps:

- Correct rotations
- Pump is properly primed before starting if pump suction is negative.

(c)Vertical turbine pumps

- Pumps properly primed before starting
- Air vent to be fully opened before starting
- Correct rotation of pump.
- Pump should not be operated, if ratchet pins are missing
- Bowl assembly is completely submerged

(d) Inventory of materials for pumps

- Submersible pumps: Impellers
- Centrifugal pumps: Impellers, diffusers, bearings, gland packing’s

- Vertical turbine pumps: thrust bearings, gland packing, head shaft, intermediate shaft, bearing spider, bowl assemble, impeller etc.
- Motors: Bearings
- MCC: Relay, tripping circuit, fuses.
- Transformer: Oil

11.2.2.1 Undesirable Operations

Following undesirable operations should be avoided:

1) Operation at Higher Head-The pump should never be operated at head higher than maximum recommended. Such operation results in excessive recirculation in the pump, overheating of the water and the pump. Another problem, which arises if pump is operated at a head higher than the recommended maximum head, is that the radial reaction on the pump shaft than the recommended maximum head, is that the radial reaction on the pump shaft increases causing excessive unbalanced forces on the shaft which may cause failure of the pump shaft. As a useful guide, appropriate marking on pressure gauge be made. Such operation is also inefficient as efficiency at higher head is normally low.
2) Operation at Lower Head-If pump is operated at lower head than recommended minimum head, radial reaction on the pump shaft increases causing excessive unbalanced forces on shaft which may cause failure of the pump shaft. As useful guide, appropriate markings on both pressure gauge and ammeter are made. Such operation is also inefficient as efficiency at lower head is normally low.
3) Operation on Higher Suction Lift-If pump is operated on higher suction lift than permissible value, pressure at the eye of impeller and suction side falls below vapour pressure. This results in flashing of water into vapour. These vapour bubbles during passage collapse resulting in cavitation in the pump, pitting on suction side of impeller and casing and excessive vibrations. In addition to mechanical damage due to pitting, discharge of the pump also reduces drastically.
4) Throttled operation-At times if motor is continuously overloaded, the delivery valve is throttled to increase head on the pump and reduce power drawn from motor. Such operation results in inefficient running as energy is wasted in throttling. In such cases, it is preferable to reduce diameter of impeller which will reduce power drawn from motor. Installation of variable voltage &variable frequency (VVVF) drive as a remedial measure is recommended
5) Operation with Strainer/Foot Valve Clogged-If the strainer or foot valve is clogged, the friction loss in strainer increases to high magnitude which may result in pressure at the eye of the impeller falling below water vapor pressure, causing cavitation’s and pitting similar to operation on higher suction lift. The strainers and foot valves should be periodically cleaned particularly during monsoon.
6) Operation with Occurrence of Vortices-If vibration continues even after taking all precautions, vortex may be the cause. All parameters necessary for vortex-free operation should be checked.

11.2.2.2 STARTING THE PUMPS

Following points should be checked before starting the pump.

- Power is available in all 3 phases.
- All connections are properly thimble
- Trip circuit for relays is in healthy state\ Check voltage in all 3 phases
- The voltage in all phases should be almost same and within + 10% of rated voltage, as per permissible voltage variation.

- Check functioning of lubrication system specifically for oil lubricated and clear water lubricated VT pumps and oil lubricated bearings
- Check stuffing box to ensure that it is packed properly.
- Check and ensure that the pump is free to rotate.
- Check overcurrent setting if the pump is not operated for a week or longer period.
- Before starting it shall be ensured that the water level in the sump/intake is above low water level and inflow from the source or preceding pumping station is adequate.

11.2.2.3 Stopping the Pump

(a) Stopping the Pump under Normal Condition

Steps to be followed for stopping a pump of low and medium specific speed are as follows:

1. Close the delivery valve gradually (sudden or fast closing should not be resorted to which can give rise to water hammer pressures).
2. Switch off the motor.
3. Open the air vent in case of V.T. and submersible pump.
4. Stop lubricating oil or clear water supply in case of oil lubricated or clear water lubricated VT pump as applicable

(b) Stopping after Power Failure/Tripping

If power supply to the pumping station fails or trips, actions stated below should be immediately taken to ensure that the pumps do not restart automatically on resumption of power supply. Though no-volt release or under volt relay is provided in starter and breaker, possibility of its malfunctioning and failure to open the circuit cannot be ruled out. In such eventuality, if the pumps start automatically on resumption of power supply, there will be sudden increase in flow velocity in the pumping main causing sudden rise in pressure due to water hammer which may prove disastrous to the pumping main. Secondly, due to sudden acceleration of flow in the pumping main from no-flow situation, acceleration head will be very high and the pumps shall operate near shut off region during acceleration period which may last for few minutes for long pumping main and cause overheating of the pump. Restarting of all pumps simultaneously shall also cause overloading of electrical system. Hence, precautions are necessary to prevent auto-restarting on resumption on power.

Following procedure should be followed.

- Close all delivery valves on delivery piping of pumps if necessary, manually as actuators cannot be operated due to non-availability of power.
- Check and ensure that all breakers and starters are in open condition i.e. off-position.
- All switches and breakers shall be operated to open i.e. off-position.
- Open air vent in case of V.T. or submersible pump and close lubricating oil or clear water supply in case of oil lubricated or clear water lubricated V.T. pump. Information about power failure should be given to all concerned, particularly to upstream pumping station to stop pumping so as to prevent overflow.

11.3 Pumping Machinery Maintenances

(a) Daily

- Clean the pump, motor and other accessories.
- Check coupling bushes/rubber spider.
- Check stuffing box, gland etc.

(i) Routine observations of irregularities

- The pump operator should be watchful and should take appropriate action on any irregularity noticed in the operation of the pumps. Particular attention should be paid to following irregularities.
- Changes in sound of running pump and motor
- Abrupt changes in bearing temperature.
- Oil leakage from bearings
- Leakage from stuffing box or mechanical seal
- Changes in voltage
- Changes in current
- Changes in vacuum gauge and pressure gauge readings
- Sparks or leakage current in motor, starter, switch-gears, cable etc
- Overheating of motor, starter, switch gear, cable etc.

(II) Record of operations and observations

A log book should be maintained to record the observations, which should cover the following items

- Timings when the pumps are started operated and stopped during 24 hours.
- Voltage in all three phases.
- Current drawn by each pump-motor set and total current drawn at the installation.
- Frequency.
- Readings of vacuum and pressure gauges.
- Motor winding temperature.
- Bearing temperature for pump and motor.
- Water level in intake/sump.
- Flow meter reading.
- Daily PF over 24 hour's duration.
- Any specific problem or event in the pumping installation or pumping system e.g. burst in pipeline, tripping or fault, power failure.

(b) Monthly Maintenance

- Check free movement of the gland of the stuffing box; check gland packing and replace if necessary. Clean and apply oil to the gland bolts.
- Inspect the mechanical seal for wear and replacement if necessary. Check condition of bearing oil and replace or top up if necessary.

(c) Quarterly Maintenance

- Check alignment of the pump and the drive. The pump and motor shall be decoupled while correcting alignment, and both pump and motor shafts shall be pushed to either side to eliminate effect of end play in bearings.
- Clean oil lubricated bearings and replenish with fresh oil. If bearings are grease lubricated, the condition of the grease should be checked and replaced/replenished to the correct quantity. An anti-friction bearing should have its housing so packed with grease that the void space in the bearing housing should be between one third to half. A fully packed housing will overheat the bearing and will result in reduction of life of the bearing.
- Tighten the foundation bolts and holding down bolts of pump and motor mounting on base plate or frame.
- Check vibration level with instruments if available; otherwise by observation.
- Clean flow indicator, other instruments and appurtenances in the pump house.

(d)Annual Inspections and Maintenance

A very thorough, critical inspection and maintenance should be performed by trained operator/Engineer once in a year.

Following items should be specifically attended.

- Clean and flush bearings with kerosene and examine for flaws developed, if any, e.g. corrosion, wear and scratches. Check end play. Immediately after cleaning, the bearings should be coated with oil or grease to prevent ingress of dirt or moisture.
- Clean bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in bearing housing.
- Examine shaft sleeves for wear or scour and necessary rectification. If shaft sleeves are not used, shaft at gland packing's should be examined for wear.
- Check stuffing box, glands, lantern ring, and mechanical seal and rectify if necessary.
- Check clearances in wearing ring.
- Check impeller hubs and vane tips for any pitting or erosion.
- Check interior of volute, casing and diffuser for pitting, erosion, and rough surface.
- All vital instruments i.e. pressure gauge, vacuum gauge, ammeter, voltmeter,
- Check performance test of the pump for discharge, head efficiency.

11.3.1 MAINTENANCE SCHEDULE FOR MOTORS

(a)Daily

- Clean external surface of motor.
- Examine earth connections and motor leads.
- Check temperature of motor and check whether overheated. The permissible maximum temperature is above the level which can be comfortably felt by hand. Hence temperature observation should be taken with RTD or thermometer. (Note: In order to avoid opening up motors, a good practice is to observe the stator temperature under normal working conditions. Any increase not accounted for, by seasonal increase in ambient temperature, should be suspected).
- In case of oil ring lubricated bearing.
    - Examine bearings to check whether oil rings are working.
    - Note bearing temperature.
    - Add oil if necessary.
- Check for any abnormal Bearing noise.

(b) Monthly

- Check belt tension. In case where this is excessive it should immediately be reduced.
- Blow dust from the motor.
- Examine oil in oil lubricated bearing for contamination by dust, grit, etc. (this can be judged from the colour of the oil).
- Check functioning and connections of anti-condensation heater (space heater).
- Check insulation resistance by mongering.

(c) Quarterly

- Clean oil lubricated bearings and replenishes fresh oil. If bearings are grease lubricated, the condition of the grease should be checked and replaced/replenished to correct the condition of the grease should be checked and replaced/replenished to correct quantity. An
- Anti-friction bearing should have its housing so packed with grease that the void space in the bearing housing should be between one third to half. A fully packed housing will overheat the bearing and will result in reduction of life of the bearing.

- Wipe brush holders and check contact faces of brushes of slip-ring motors. If contact face is not smooth or is irregular, file it for proper and full contact over slip rings.
- Check insulation resistance of the motor.
- Check tightness of cable gland, lug and connecting bolts.
- Check and tighten foundation bolts and holding down bolts between motor and frame.
- Check vibration level with instrument if available; otherwise by observation.

(d) Half Yearly

- Clean winding of motor, bake and varnish if necessary.
- In case of slip ring motors, check slip-rings for grooving or unusual wear, and polish with smooth polish paper if necessary.

(e) Annual Inspections and Maintenance

- Clean and flush bearings with kerosene and examine for flaws developed, if any, e.g. wear and scratches. Check end-play. Immediately after cleaning, the bearings should be coated with oil or grease to prevent ingress of dirt or moisture.
- Clean bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in bearing housing.
- Blow out dust from windings of motors thoroughly with clean dry air. Make sure that the pressure is not so high as to damage the insulation
- Clean and varnish dirty and oily windings. Re-varnish motors subjected to severe operating and environmental conditions e.g., operation in dust-laden environment, polluted atmosphere etc.
- Check condition of stator, stamping, insulation, terminal box, fan etc.
- Check insulation resistance to earth and between phases of motors windings, control gear and wiring.
- Check air gaps.
- Check resistance of earth connections.

11.3.2 History Sheet

Similar to history sheet of pump, history sheet of motor should be maintained. The history sheet should contain all important particulars, records of periodical maintenance, repairs, Inspections and tests. It shall generally include the following

- Details of motor, rating, model, class of duty, class of insulation, efficiency curve, type test result and type test certificate etc.
- Date of installation and commissioning.
- Addresses of manufacturer & dealer with phone & fax number and e-mail addresses.
- Brief details of monthly, quarterly, half yearly and annual maintenance and observations of inspections about insulation level, air gap etc.
- Details of breakdown, repairs with fault diagnosis.
- Running hours at the time of major repairs.

11.3.3 L.T.STARTERS, BREAKERS AND PANEL

Note: Circuit diagram of starter/breaker should be pasted on door of switch gear and additional copy should be kept on record.

a) Daily

- Clean the external surface.
- Check for any spark or leakage current.
- Check for overheating.

b) Monthly

- Blow the dust and clean internal components in the panel, breaker and

- Check and tighten all connections of cable, wires, jumpers and bus-bars. All carbon deposits shall be cleaned.
- Check relay setting.

c) Quarterly

- Check all connections as per circuit diagram.
- Check fixed and moving contacts and clean with smooth polish paper, if necessary.
- Check oil level and condition of oil in oil tank. Replace the oil if carbon deposit in suspension is observed or color is black.
- Check insulation resistances.
- Check conditions of insulators.

d) Yearly

- Check and carry out servicing of all components, thoroughly clean and reassemble.
- Calibrate voltmeter, ammeter, frequency meter etc.

11.3.4 H.T.Breakers, Contactors and Protection Relays

Note: Circuit diagram of breaker/relay circuit should be pasted on door of switch gear and additional copy should be kept on record. Maintenance schedule specified for L.T. breakers are also applicable to H.T. breakers and contactors. In addition, following important points shall be attended for H.T. breakers and contactors.

a) Monthly

- Check spring charging mechanism and manual cranking arrangement for operation.
- Clean all exposed insulators.
- Check trip circuit and alarm circuit.
- Check opening & closing timing of breaker.

b) Quarterly

- Check control circuits including connections in marshaling boxes of breakers and transformer.
- Check oil level in MOCB/LOCB/HT OCB and top up with tested oil.
- *Yearly / Two yearly*1 Testing of protection relay with D.C. injection shall be carried out once in year.
- Servicing of HT breaker and contactor shall be carried out once in 2-3 years.
- Check dielectric strength of oil in breaker and replace if necessary.
- Check male & female contacts for any pitting and measure contact resistance.

11.3.5 Transformer & Transformer Substation

Maintenance schedule as follows shall be applicable for transformer and sub-station equipment's e.g. Lightening arrestor, A.B. switch, D.O. or horn gap fuse, sub-station earthling system etc.This Para is particularly useful for the large schemes. Instructions of state electricity department and chief electrical inspector shall be followed.

a)Daily Observations and Maintenance

- Check winding temperature and oil temperature in transformer and record. (For large transformers above 1000 kV, the temperature should be recorded hourly).
- Check leakages through CT/PT unit, transformer tank and HT/LT bushings.
- Check colour of silica gel. If silica gel is of pink colour, change the same by spare charge and reactivate old charge for reuse.

b)Monthly

- Check oil level in transformer tank and top up if required.
- ii) Check relay contacts, cable termination, connections in marshaling box etc.
- Check operation of AB switch and DO fuse assembly.
- Clean radiators free from dust and scales.
- Pour 3-4 buckets (6 to 8 buckets in summer) of water in earth pit. Watering shall be increased to once in a week in summer season. Watering shall be increased to once in a week in summer season. shall preferably contain small amount of salt in solution.
- Inspect lightning arrestor and HT/LT bushing for cracks and dirt.

c) Quarterly

- Check dielectric strength of transformer oil and change or filter if necessary.
- Check insulation resistance of all equipment's in sub-station, continuity of earthlings and earth leads.
- Check operation of tap changing switch.

11.3.6 Pre-Monsoon and Post-Monsoon Checks and Maintenance

- Check insulation resistance of transformer.
- Test transformer oil for dielectric strength, sludge etc. If necessary, filtration of oil shall be carried out before monsoon.
- Oil shall be tested for dielectric strength after monsoon.

a)Half-Yearly

- Check dielectric strength of transformer oil in CT/PT and filter or change oil if necessary.
- Check contact faces of AB switch and DO/HG fuse; apply petroleum jelly or grease to moving components of AB switch.

b) Annual

- Measure resistance of earth pit. Resistance shall not exceed 1 ohm.
- Check bus bar connections, clean contact faces, change rusted nut bolts.
- Calibrate the protection relay for functioning. Check relay setting and correct if necessary.
- Ensure that sub-station area is not water-logged. If required necessary earth fillings with metal spreading at top shall be carried out once in a year. Check drainage arrangement to prevent water logging in substation area and cable trenches.
- Test transformer oil for acidity test.

c) Special Maintenance

- Painting of transformer tank and steel structure of sub-station equipment's shall be carried out after every two years.
- The core of transformer and winding shall be checked after 5 years for transformer up to 3000 kVA and after 7–10 years for transformers of higher capacity.

CHAPTER – 12

WATER METERS, INSTRUMENTATION TELEMETRY & SCADA

12.1 Water Meters

A water meter is a scientific instrument for measurement of quantity of water distributed to the consumers. It also fulfills the need to know accurately the water produced and distributed. Water meter is always specified in two accuracies i.e. lower range and upper range accuracies. The upper range and lower range accuracies are 2% and 5% of the actual quantity respectively for the water meter. Water meters having sizes from 15 mm to 50 mm as per BIS 779 are considered to be domestic water meters and sizes from 50 mm and above as per BIS 2373 are considered to be Bulk Water Meters. There are different types of water meters such as mechanical water meter, electro-mechanical, ultra-sonic water meters etc.

12.1.1 Sizing of Water Meters

Sizing of water meter is done keeping in view the guidelines given in Indian standard IS 2401 and ISO 4064 part-II. In general main considerations are as follows:

- Water meter has to be selected according to the flow to be measured and not necessarily to suit a certain size of water main.
- The maximum flow shall not exceed the maximum flow rating.
- The nominal flow shall not be greater than the nominal flow rating.
- The minimum flow to be measured shall be within the minimum starting flow of the meter.
- Low head loss, long operating flow range, less bulky and robust meter shall be preferred.

12.1.2 Installation of Water Meters

In order to ensure proper working of the meters, BIS has given guidelines in IS-2401 of 1973for their installation as per the drawing given in it. The following guidelines should be borne in mind while installing the meters.

- The water meter being a delicate instrument shall be handled with great care. Rough handling including jerks or fall is likely to damage it and affects its accuracy.
- The meter shall be installed at a spot where it is readily accessible. To avoid damages and over run of the meter due to intermittent water supply system, it is always advisable to install the meter, so that the top of the meter is below the level of the communication pipes so that meters always contains water, when there is no supply in the line. Also, the minimum straight length condition as per the drawing shall be observe
- The meter shall preferably be housed in a chamber with a lid for protection; it should never be buried underground nor installed in the open nor under a water tap so that water may not directly fall on the meter. It should be installed inside inspection pits, built out of bricks or concrete and covered with lid. It should not be suspended.
- The meter shall be so installed that the longitudinal axis is horizontal and the flow of water should be in the direction shown by the arrow cast on body.
- Before connecting the meter to the water pipe, it should be thoroughly cleaned by installing in the place of the water meter a pipe of suitable length and diameter and letting the passage of a fair amount of water flow through the pipe work to avoid formation of air pockets. It is advisable that the level of the pipeline where the meter is proposed to be installed should be checked by a spirit level.
- Before fitting the meter to the pipeline check the union's nuts in the tail pieces and then insert the washers. Thereafter screw the tail pieces on the pipes and install the meter in between the nuts by screwing. In order to avoid its rotation during the operation, the meter

should be kept fixed with suitable nonmetallic clamps. Care should be taken that the washer does not obstruct the inlet and outlet flow of water.

- The protective lid should normally be kept closed and should be opened only for reading the dial.
- The meter shall not run with free discharge to atmosphere. Some resistance should be given in the down side of the meter if static pressure on the main exceeds 10 m. head.
- A meter shall be located where it is not liable to get severe shock of water hammer which might break the system of the meter.
- Owing to the fine clearance in the working parts of the meters they are not suitable for measuring water containing sand or similar foreign matter and in such cases a filter or dirt box of adequate effective area shall be fitted on the upstream side of the meter. It should be noted that the normal strainer fitted inside a meter is not a filter and does not prevent the entry of small particles, such as sand.
- In case of intermittent water supply to SR and schemes with storage at higher elevation, the bulk water meter may be provided with a suitable air valve before the meter in order to reduce inaccuracy and to protect it from being damaged.

12.1.3Testing and Calibration of Water Meters

The testing & calibration of a water meter is essential before putting it into use as it is a statutory requirement and may be done periodically in order to ascertain its performance. It is likely that its accuracy of measurement may deteriorate beyond acceptable limits in course of its use.
A meter suspected to be malfunctioning is also tested for its accuracy of measurement. The testing is done as per IS6784/ISO4064 part III. A faulty meter if found to be repairable, is repaired and tested and calibrated for its accuracy before installation .The metering accuracy testing is carried out at Qmin, Qt& Qmax. Separately Where:

- Qmin: Lowest flow rate at which the meter is required to give indication within the maximum permissible error tolerance. It is as mentioned in IS779 and is determined in terms of numerical value of meter designation in case of ISO 4064.
- Qt: The flow rate at which the maximum permissible error of the water meter changes in value.
- Qn: Half the maximum flow rate Q max.
- Qmax : The higher flow rate at which the meter is required to operate in a satisfactory manner for short periods of time without deterioration.
- The accuracy of water meter is divided into two zones i.e.
    a. Lower measurable limit in which +5% accuracy from minimum flow to transitional flow (exclusive) and
    b. Upper measurable limit in which +2% accuracy from transitional flow (inclusive) to maximum flow.

12.1.4 Repairs, Maintenance & Trouble Shooting of Water Meters

The water meters are mechanical devices, which normally deteriorate in performance over time. The fact that a meter does not show outward signs of any damage and has a register that appears to be turning does not mean that the meter is performing in a satisfactory way.

It is necessary to ascertain the following preventive cares for water meter after proper installation:

(a) Preventive maintenance:-

- Proper handling, storage and transportation of water meters.
- To clean the dirt box or strainer wherever installed.
- To replace the gaskets, if any
- To clean the chamber in which the meter is installed and keep free from flooding, & seepage.

- To remove the meter for further internal repair/replacement if it does not show correct reading pattern.

(b) Breakdown maintenance:-

Replacement of broken glass, lid and fallen wiper wherever provided: - These are the only basic breakdowns observed during periodical inspection. If a meter found not working, then it shall be removed immediately and sent to meter service workshop. In meter workshops normally following steps are performed to carry out the repairs:

- Disassembling of water meters including strainer, measuring unit, regulator, registering device, etc.
- Clean all disassembled spare parts in detergent solution in warm water.
- Inspect the cleaned parts and replace worn parts and gaskets, if any.
- Inspect the meter body spur threads and cover threads.
- Inspect the sealing surface on meter body and paint the meter body, if necessary.
- Inspect the vane wheel shaft pinion, bearing & pivot.
- Inspect the vane wheel chamber.
- Reassemble the water meter properly after reconditioning.
- Calibrate & test the repaired water meter for leakage & accuracy as per IS 678410. Make entry in the life register of that water meter for keeping history record.

12.1.5 Prevention of Tampering Of Water Meters

In order to prevent tampering, following precautions should be taken:

- The water meters, shall be installed properly in the chamber with lock and key or in the C.I. covers with lock and key in order to avoid tampering.
- The water meters must be sealed properly.
- The water meters shall not allow reversible flow; it should register flow in forward directions only.
- The water meter dials should be easily readable without confusions.
- The lid, glass of water meters must be made up of tough materials as per IS 779 and shall be replaced timely.
- The wiper or dial as far as possible is avoided.
- In case of magnetically coupled meters, the proper material to shield magnets must be provided in order to avoid the tampering of such meter by outside magnets in the vicinity of meter.
- Periodical inspection/checking at site is essential to ensure the proper working of meter.
- Special sealing arrangements may be necessary and provided for bulk meters where by unauthorized removal of the meter from the connection can be detected. In addition to the above, to tackle the problems of tampering suitable penalty provisions/clauses shall be there in the rules or the water supply agreement with the consumer. This will also discourage the consumer tendencies of neglecting water meter safety.

12.1.6 Automatic Water Metering Systems

Water meter is a cash register of a water supply agency/VWSC. Consumption based water rates require periodic reading of meters except in remote or automated meter reading of meters. Except in remote or automated meter reading these readings are usually done by meter readers visiting consumers premises one by one and noting down the indicator reading by the meter. These readings are recorded manually in books or on cards and later keyed in manually to a customer accounting or billing system. In some cases, meter readers use Hand held Data Entry Terminals to record meter readings. Data from these devices are transferred electronically to a billing system. In other cases, key entry has been replaced by mark-sense card readers or optical scanners.

The environment of meter reading usually is not favorable to the meter reader as most of the water meters are installed in underground chamber; these chambers are filled in many cases with water, reptiles or insects. In some consumers connect their electrical earth terminal to water utility pipe which endangers the safety of meter reader or premises are not accessible the meter reader. The solution to above difficulties is to install automatic system to read meters and process the results by computer.

The data can be captured by the meter readers from the meter in one of the following ways.

- Manual entry into meter books.
- Manual entry into portable hand held entry terminals or recorders.
- Direct electronic entry from meter registers either into portable data terminals or display units from which readings are transcribed in the field.
- Telemetry link through radio, telephone.

12.2 Instrumentation

Presently there is a lack of instrumentation in rural water supply sector but in future more instrumentation is expected to be practiced in the following areas:

12.2.1 Level Measurement

Instrumentation facilitates coordination of various water parameters, which are essential for optimization of water supply & treatment plant. One of the important parameters amongst them is water level measurement, which is carried out at various locations vis. water reservoir, inlet chamber, open channel, alum feeding tank, lime tank, filter beds, air vessel, sump well etc.

This measurement is accomplished in water works by two following ways:

- Direct Method
- Inferential Method

12.2.2 Pressure Measurement

In water supply network pressure parameter plays very important role in order to get sufficient water to the consumers. Similarly in flow measurement by differential pressure type flow meter, differential pressure measurement across the primary element is the main physical parameter to inter link with flowing fluid. This pressure or differential pressure measurement is accomplished with the help of following methods in water works:

- Manometers
- Elastic Pressure Transducer
- Electrical Pressure Transducer

12.2.3 Capacitors:

Capacitors are needed to be provided invariably in all the pumping stations for maintaining required power factor thereby savings of energy. Pre-requisites for Satisfactory Functioning of Capacitors Ensure following points:

- A capacitor should be firmly fixed to a base.
- Cable lugs of appropriate size should be used.
- Two spanners should be used to tighten or loosen capacitor terminals. The lower nut should be held by one spanner and the upper nut should be held by the spanner to avoid damage to or breakage of terminal bushings and leakage of oil.
- To avoid damage to the bushing, a cable gland should always be used and it should be firmly fixed to the cable-entry hole.

- There should be a clearance of at least 75 mm on all sides for every capacitor unit to enable cooler running and maximum thermal stability. Ensure good ventilation and avoid proximity to any heat source.
- While making a bank, the bus bar connecting the capacitors should never be mounted directly on the capacitor terminals. It should be indirectly connected through flexible leads so that the capacitor bushings do not get unduly stressed.
- Ensure that the cables, fuses and switchgear are of adequate ratings.

12.2.3.1 Operation and Maintenance of Capacitors

- The supply voltage at the capacitor bus should always be near about the rated voltage. The fluctuations should not exceed + 10% of the rated voltage of the capacitor.
- Frequent switching of the capacitor should be avoided. There should always be an interval of about 60 seconds between any two switching operations.
- The discharge resistance efficiency should be assessed periodically by sensing, if shorting is required to discharge the capacitor even after one minute of switching off. If the discharge resistance fails to bring down the voltage to 50V in one minute, it needs to be replaced.
- Leakage or breakage should be rectified immediately. Care should be taken that no appreciable quantity of imp- regnant has leaked out.
- Before physically handling the capacitor, the capacitor terminals shall be shorted one minute after disconnection from the supply to ensure total discharging of the capacitor.
- Replace capacitor if bulging is observed.

12.2.2 Water Hammer Control Devices

Maintenance requirements of water hammer devices depend on type of water hammer control device, nature of its functioning, water quality etc. Type of water hammer control devices used in water pumping installations is as follows:

- Surge tank and/One-way surge tank.
- Air vessels (air chamber).
- Zero velocity valve and air cushion valve.
- Surge anticipation valve (surge suppressor).
- Pressure relief valve.

General guidelines for maintenance of different types of water hammer control devices as follows:

(1)Surge Tank and One-Way Surge Tank

Quarterly:

- Water level gauge or sight tube provided shall be inspected, any jam rectified,
- all cocks and sight tube flushed and cleaned.

Yearly:

- *The* tank shall be drained and cleaned once in a year or earlier if frequency of ingress of foreign matter is high.

(2) Valve maintenance:

- Maintenance of butterfly valve, sluice valve and reflux valve shall be attended
- *Painting:* Painting of tanks shall be carried out once in 2 years.

(3) Air-Vessel

Daily:

- Check air-water interface level in sight glass tube.

- The air water level should be within range marked by upper and lower levels and shall be preferably at middle.
- Check pressure in air receiver at interval of every 2 hours.

Quarterly:

- Sight glass tube and cock shall be flushed.
- All wiring connections shall be checked and properly reconnected.
- Contacts of level control system and pressure switches in air supply system shall be cleaned.

Yearly:

- The air vessel and air receiver shall be drained, cleaned and dried.
- Internal surface shall be examined for any corrosion etc. and any such spot cleaned by rough polish paper and spot-painted.
- Probe heads of level control system shall be thoroughly checked and cleaned a*ccessories :*
- Maintenance of panel, valves and air compressor etc. shall be carried out as
- Maintenance of panel, valves and air compressor etc. shall be carried out as specified for respective appurtenances.

(4) Zero-Velocity Valves and Air Cushion Valve

Foreign matters entangled in valve shall be removed by opening all hand holes and internal components of the valves including ports, disk, stem, springs, passages, seat faces etc. should be thoroughly cleaned and checked once in 6 months for raw water and once in a year for clear water application.

12.3 Telemetry and SCADA Systems

12.3.1 Manual Monitoring

Normally the Managers of O&M of water scheme monitor levels in Service reservoirs, pressures and flows in a distribution system and on operation of pumps such as hours of pumping and failure of pumps and monitor water quality by measuring residual chlorine. The line department usually uses the telephone line or wireless unit to gather the data, uses his discretion gained with experience and takes decisions to ensure that the system is operating with required efficiency. Manual collection of data and analysis may not be helpful in large undertakings if water utilities have to aim at enhanced customer service by improving water quality and service level with reduced costs. This is possible if the management acquires operational data at a very high cost.

12.3.2 Telemetry

The inspection, monitoring and control of O&M of a water utility can be automated partially through telemetry. Telemetry enables regular monitoring of the above data on real time basis and the data is provided to anyone in the organization who can review the data and take decision. In Telemetry system probes/sensors will be used which will sense and generate signals for the level, pressure and flow in a given unit and transmit the signals by radio/by Telephone. Normally radio link is used and telephone line with modem is used as spare communication. Microwave satellite or fiber- optic transmission systems are also used for data transmission. The water pumping stations may communicate via a cable buried with the pipe. However there may be locations where the main power may not be available and hence solar panels with a battery charger are used to power the remote terminal unit (RTU) and the radio. In urban areas RTU s can communicate on cell phones and or packed radio networks. For remote locations satellite technology is also available.

(i)Data for collection by telemetry

The data includes levels in Service reservoirs, pressures and flows in a distribution system, Flows/quantity of delivered into a SR and data on operation of pumps such as Voltage, amperes, energy consumed, operating times and down times of pumps and chlorine residuals. In a telemetry system up-to the minute real time information is gathered from remote terminal unit located at the water treatment plant, reservoir, flow meter, pumping station etc. and transmitted to a central control station where the information is updated, displayed and stored manually or automatically.

(ii) Processing data from telemetry

The meter readings from reservoirs are useful information for managing the distribution system and helps in preventing overflow from reservoirs. However the effectiveness of Telemetry in pumping operations is dependent on reliability of instrumentation for measuring flows, pressures, KWh meters, etc. Standard practice is to calculate pump efficiency and water audit calculations on a monthly basis. Telemetry can also be used to supervise water hammer protection system wherein the pump failures are linked to initiate measures to prevent occurrence of water hammer.

(iii)SCADA Systems (Supervisory Control and Data Acquisition)

Supervisory Control and Data Acquisition (SCADA) systems provide control functionality and alarms at rural water supply scheme sites which in many cases are very remote. These systems were often used to solve single problems such as reducing power cost, or improving control of a particularly complex operation. The installation of SCADA has subsequently been seen as a means to satisfy a variety of increasing pressures such as consumer demands, regulatory requirements, and to also satisfy the need to reduce operational costs. The deployment of SCADA systems has been extended to cover large rural water supply schemes and has been found very effective.

An important challenge to the commercial success of the organization is to harness the data collection power of the SCADA systems to provide a wealth of operational information to all levels of the organization. Past systems that have been installed in some of the water treatment plants have failed to meet expectations regarding data availability. This has primarily been attributed to difficulties associated with merging traditional engineering and new IT methodology, and a lack of system openness in data interconnectivity and communications.

(iv) Remote Terminal Units (RTU)

A Remote Terminal Unit (RTU) is a microprocessor-controlled electronic device that interfaces objects in the physical world to a SCADA (supervisory control and data acquisition system) by transmitting telemetry data to the system and/or altering the state of connected objects based on control messages received from the system. Modern RTUs are usually capable of executing simple programs autonomously without involving the host computers of SCADA system to simplify deployment, and to provide redundancy for safety reasons. An RTU in a modern water management system will typically have code to modify its behavior when physical override switches on the RTU are toggled during maintenance by maintenance personnel. This is done for safety reasons; a .miscommunication between the system operators and the maintenance personnel could cause system operators to mistakenly enable power to a water pump when it is being replaced, for example.

Further the following preferences relevant national & International Standards on meters are available:

- IS 779-1994: Water meters (Domestic type) – Specification (Sixth revision).
- IS 2373-1981: Specifications for water meters (Bulk type) (Third revision)
- IS: 6784: Testing of Water meter4.
- BS: 5728: Measurement of water flow in close conduits,
- Part-I: Specifications for meters for cold potable Water
- Part – II : Specification for installation requirements for meters

- Part – III: Methods for determining principal characteristics of meters.
- ISO: 4064: Measurement of water flow in close conduits,
- Part-I-Specification for meters for cold potable Water.
- Part – II : Installation requirement
- Part – III: Test methods and equipment

CHAPTER – 13

DRINKING WATER QUALITY MONITORING AND SURVEILLANCE

13.1 Introduction

Drinking water quality monitoring and surveillance of a water supply schemes is the continuous monitoring of public health along with vigilant assessment and control of safe potable water supply. The Ministry of Drinking water and Sanitation has launched a National Drinking Water Quality monitoring and surveillance programme in 2006.The relevant guidelines and procedures including protocols shall be followed by the states/UTs.

13.2 Importance of Water Quality

Safe potable water is the first step to promote good health of the community. Experience has shown that community health and water quality is directly related to each other and an improvement of drinking water quality is followed by an improvement in the community's health. Manmade activities; rapid industrialization and agro-chemical contamination increasingly affect the quality of water resources. Moreover, infant mortality, mostly from diarrheal and other water borne and water related diseases are of great concern in underdeveloped as well as developing countries. In spite of significance achievements in water supply and sanitation coverage, many factors render good quality water unsafe by the time it reaches the consumer. Poor operation management and unsatisfactory sanitary practices are the major key areas responsible for water contamination. Water quality management and surveillance practices ensure safe water supply to consumers.

13.3 Definition

While describing water quality, certain terms are frequently used, which are to be clearly understood and correctly used. Some of the definitions are given below:

- ***Pollution*** is the introduction in to water of substance in sufficient quantity to affect the original quality of water, make it objectionable to sight, taste, smell or make it less useful.
- ***Contamination*** is the introduction into water of toxic materials, bacteria or other deleterious agents that make the water hazardous and therefore unfit for human use.
- ***Potable Water*** that is satisfactory for drinking purposes from the standpoint of its chemical, physical and biological characteristics. Palatable Water that is appealing to the sense of taste, sight and smell. Palatable water need not always be potable.
- ***Parts per million (ppm) or milligrams per liter (mg/l)*** these terms are used to express the concentrations of dissolved or suspended matter in water. The parts per million (ppm) is aweigh to weight or volume to volume relationship. Except in highly mineralized water, this quantity would be same as milligram per liter. This is preferable, since it indicates how it is determined in the laboratory.
- ***pH*** *of water is* an expression of the Hydrogen ion concentration. Alkaline water is with pH of above 7 and acidic water has pH of below 7 whereas water with pH 7 is neutral. ***Physiological effect*** - *having* effect on the normal functions of the body. *Pathogens* disease- producing organisms.
- ***Bacteria***-a group of universally distributed, essentially unicellular microorganisms lacking chlorophyll.
- ***Virus*** - the smallest form capable of producing infection and diseases in human beings.

- ***Coliform Bacteria***-group of bacteria predominantly inhabiting the intestine of human being sand animals, but also occasionally found elsewhere. Used to indicate presence of fecal-pollution.
- ***Enteric***-having its normal habitat in the intestinal tract of human beings or animals.
- ***Chlorine Residual***-chlorine remaining in the water at the end of a specified period.
- ***Chlorine Demand*** -the difference between the amounts of chlorine added to water and amount of residual chlorine remaining in the water at the end of a specified period.

13.4 Water Supply and Surveillance Agencies

Water supply agency/VWSC is responsible for safe water supply to consumers. The main objectives of water quality monitoring are:

1. To determine the quality of water in its natural state in view of its present and future needs
2. To assess the suitability of water for required use
3. To find out the pathways for pollution, if any

Monitoring of water quality by water supply agency involves laboratory and field testing of water samples collected from various points in the water supply system, including the source, water purification plants, service reservoirs distribution systems and consumer end, representative of the condition of water at the point and time of collection. Continuous water quality monitoring involves good operating practices and preventive maintenance, as well as the regular routine testing, and monitoring of water quality to ensure compliance with standards.

Surveillance is an investigative activity undertaken by a separate agency, to identify and evaluate factors posing a health risk to drinking water. Surveillance requires a systematic program of surveys that combine water analysis and sanitary inspection of institutional and community aspects, and reporting system. Sanitary inspection of water supply system should cover the whole system including water sources, rising mains, treatment plants, storage reservoirs, and distribution systems; to identify most common risks and shortcomings in the water supply. Moreover, surveillance is concerned with all sources of water used for domestic purpose by the population, whether supplied by a water supply agency or collected from other individual sources. So it is important to inspect and analyse all sources of water used and intend to be used for human consumption.

Surveillance agency should communicate to the water supply agency and pinpoint the risk areas and give advice for remedial action. It should also maintain good communication and cooperation with water supply agency for detection of risk areas and remedial action for betterment of water supply.

13.5 Planning And Implementation

Systematic planning, keeping in view the fundamental objectives, is necessary for successful implementation of drinking water quality control program.

13.6 General Consideration and Strategies

Quality control activities should be initiated as per the norms of national guidelines for each water supply system on a continuous basis.
Surveillance agency should carry out periodic surveillance of all aspects of water quality safety including sanitary inspection and spot checks and result should be reported to the concerned water supply agency to implement remedial action when and where necessary.
Water supply surveillance can be planned in progressive manner considering the availability of resources. It should start with a basic program, which could generate useful data to plan advanced surveillance as resources, and conditions permit. The initial pilot scale program should cover minimum basic strategies including fewer water quality parameters that provide reasonable degree

of public health protection and should be widely applicable. Careful planning of training and resource provision is very essential right from the beginning of the project.

13.7 Surveillance Program

Surveillance activities differ from region to region; between urban and rural communities; and according to the types of water supply. They should be adapted to local conditions; availability of local finances, infrastructure and knowledge. Water supply provider and surveillance agencies, depending on resources available with tem, will develop the program for monitoring and surveillance of drinking water quality. Following factors should be taken into consideration while implementation of surveillance activities.

- The type and size of water supply systems.
- The existing and available equipment.
- Local employment practices and the level of training.
- Opportunities for community participation.
- Accessibility of systems keeping in view of geographical and climatologically conditions
- Communication and transport facilities available.

13.8 Information Management

The flow of information between and within the water supply and surveillance agencies is necessary to maximize the quality of service to consumer and protection of public health. The report provided by the surveillance agency to water supply provider should include:

1. The summary reports of condition of water supply and water quality analysis.
2. Highlight those aspects, which are considered inadequate and needs action.
3. Recommendation of remedial action in case of emergency.

The report should not be limited to complain about failures but the water supply and surveillance agencies should coordinate their activities to ensure good quality of water to consumers. Such a report should specify actions in order of priorities for intervention based on public health criteria. If consistently, unsatisfactory results are reported in a particular area, ‘the cause for the same should be investigated and remedial measures taken, such as repair of leakage, replacement of corroded and leaking consumer pipes etc. Inspections and water analysis of all water supplies available in the area. It should include the results of all inspections and analysis. The local surveillance office should report to the relevant supply agency as soon as possible after field visits. The information should also be passed on to regional authorities to allow follow-up; if recommendations for remedial action are not implemented. However, there must be a rapid means of reporting in case of emergency.

The consumers have the right to know about the quality of water being supplied to them. Therefore, the agencies responsible for monitoring should develop strategies for informing public the health-related results obtained by them along with recommendations for action (e.g. boiling during severe fecal contamination, household water storage education etc.) through publicity, Pani-Panchayats etc.

Local government should ensure that the agency that supplies drinking water to the area complies with the quality standards.

13.9 Support Structure

Monitoring and surveillance program require laboratory network, offices, transport, financial support and adequate staffing.

13.10 Community Based Monitoring and Surveillance

Community participation is an essential component of the monitoring and surveillance frame-work. As the primary beneficiaries community can play an important role in surveillance activity. They are the people who may first notice the problems in water supply and report it to concerned agency or take remedial action if possible. Establishing a genuine partnership with the community creates a climate of trust and understanding, which generates interest and enthusiasm. It also provides a good foundation for other educational activities such as promotion of good hygiene practices. The community based monitoring and surveillance can be carried out in two ways:

1. Selection of community volunteers, including women, to undertake surveillance activities after training.
2. Providing encouragement to local worker to carry out certain jobs pertaining to surveillance.

In both the cases, preliminary training is necessary for field workers to identify sanitary hazards associated with the water supply, as well as regarding reporting system.

Health department or water supply agency should help in providing necessary training while community water committee or health committee can supervise the work. The community participation includes:

- Assisting field workers in water sample collection, including sample location points, existing damaged networks, causing/likely to cause contamination of drinking water.
- Assisting in data collection.
- Monitoring water quantity, quality, and reporting findings to surveillance staff regularly.
- Ensuring proper use of water supply.
- Setting priorities for sanitation and hygiene and educate community members.
- Under-take simple maintenance and repair work. Refer problems which require special attention.
- Disseminate results and explain the implications with respect to health with the objective to stimulate involvement in actions to keep water clean, safe and wholesome.

13.11 Surveillance Action

Surveillance action comprise of:

- Investigative action to identify and evaluate all possible factors associated with drinking water, which could pose a risk to human health.
- Ensure preventive action to be taken to prevent public health problem.
- Data analysis and evaluation of surveys.
- Reporting to concerned authorities.

13.12 Sanitary Survey

Sanitary survey is periodic audit of all aspects of all water supply system. Systematic program of sanitary survey includes sanitary inspection, water quality analysis, and evaluation of data and reporting.

13.12.1 Nature and Scope

Sanitary survey is an on-site inspection and evaluation of all conditions, devices and practices used in water supply system, which pose an actual or potential danger to the health and well-being of consumer by trained persons. It is a fact-finding activity, which identifies actual sources of contamination as well as point out inadequacies in the system that could lead to contamination.
The two important activities of sanitary survey are sanitary inspection and water quality analysis; which are complementary to one another. The inspection identifies potential hazards, while analysis indicates actual quality of water and intensity of contamination.

13.12.2 Sanitary Inspection

Sanitary inspection covers the inspection of water system, including the source, transmission mains, treatment plants, storage reservoirs and distribution system. Basically it is a fact-finding review to uncover deficiencies and inadequacies, which could lead to contamination of water sanitary inspection is indispensable for the adequate interpretation of laboratory results. It provides essential information about the immediate and ongoing possible hazards associated with a community water supply. It is an essential tool to tiny floc target areas for remedial action, required to protect and improve the water supply system.

13.12.3 Sanitary Inspection Report

The sanitary inspection report shall cover the following:

- Identify potential sources and points of contamination of the water supply.
- Quantify the hazards attributed to the source and supply.
- Provide a clear, graphical means of explaining the hazards to the operator/user.
- Provide clear recommendations for taking remedial actions, to protect and improve the supply.
- Provide basic data for use in systematic, strategic planning for improvement Moreover inspection report should not be restricted to water quality but should take in to account other service condition such as coverage, cost, condition and quantity.

Such surveys are important from the point of view of operation and maintenance

13.12.4 Work Chart for Sanitary Survey

For collection of adequate information and follow-up work, proper work chart should be prepared considering local requirement. Following should be taken care of:

- Prior knowledge of source, and type of water supply; and map of distribution system.
- Notify the visit in advance, where the assistance of community members is needed.
- Carry prescribed forms and necessary accessories, like sample bottle, sample carry box, analysis kit etc.
- Verify basic data with community.
- Interview community members for drinking water supply quality.
- Verify information gathered by observation during survey.
- Inspection and water sampling should not be haphazard, should follow specific guideline.
- Water samples should be analyzed immediately for residual chlorine and thermo tolerant coliform, or transported quickly to laboratory in iced boxes.
- Complete the sanitary report on site, and send it immediately to appropriate authority for follow-up remedial action if necessary.
- Undertake appropriate small repairs at the time of survey in remote areas such as washer changing for leaking taps.
- For pictorial forms, each risk point should be circled and given to member of water committee for follow-up action.

13.13 Water Sampling and Analysis

Periodic drinking water analysis is necessary to ensure safe quality water supply. Water samples should be analyzed for various microbiological and physic chemical contaminants.
However, the authenticity of water analysis greatly depends on the sampling procedure.
The objective of sampling is to collect a small portion of water which can be easily transported to laboratory, without contamination or deterioration and which should accurately represent the water being supplied. It should cover locations which are most venerable in the supply system. For recommended sampling procedures and guideline values regarding physical and chemical parameters, kindly refer to Manual on Water Supply and Treatment, III Edition, May1999

13.14 Data Analysis, Interpretation and Reporting

Data analysis and interpretation are fundamental components of surveillance process. It aims at generation of data, which contributes to protect public health by promoting adequate, safe, potable water supply to communities.

13.14.1 Data Analysis

Evaluation of community water supply requires consideration of number of factors, such as quality, quantity, coverage, continuity of water supply and never the least, its production cost.

Quantity Along with quality of supplied water to the community plays an important role for maintenance and improvement of public health. Personal and domestic hygiene greatly depends on per capita quantity of water supply to the consumers. In case of inadequate quantity of water supply, community may use alternate source of water, some of which may not be safe and affect the public health.

13.15 Use of Field Water Testing Kit (FTK)

The field water testing kit is a simple device, which can be used for testing some critical water quality parameters in the field as it gives first-hand information on the quality of water. Whenever 100% accuracy is needed then laboratory test shall be carried out. This water testing kit can be used for regular Water Quality Monitoring Programs to be conducted at Village level. Panchayat level functionaries, NGOS and students of even 7^{th} and 8^{th} standards can easily do the experiments using this kit. The details of water sources and the quality of water in many villages can be collected and the data computerized at Panchayat level. The data will be much useful in planning and formulating various water supply schemes and will be useful for proper maintenance of rural water supply schemes. The kits can be used in Schools to promote the knowledge on water quality and help to develop a good practice and scientific culture among the students.

Water Testing Methodology

For testing the water in the field, the following aspects have to be clearly understood.

- Sampling procedures.
- Testing procedures.
- Reporting.

I. Sampling Procedure: (to be included as annexure)

- Before sampling, the source should be flushed adequately.
- For hand pump sources, before collecting the water, the water should be pumped for at least three to five minutes to clear all dirt, turbidity and slime.
- Water from wells should be taken in the middle at mid depth.
- For lakes, rivers and dams, the water should be collected near the off take point.
- The water should be collected after clearing the suspended and floating matter.
- Water for chemical examination should be collected in a clean white 250 ml capacity leak proof polythene container.
- Before collection of sample the container should be washed, rinsed with the water to be sampled for at least two to three times.
- The water should be then filled completely in the container without leaving any air space.
- Place a polythene sheet (10x10cm) over the cap and tie it with a rubber band or twine thread to avoid any leak
- Write the field code number (sample ID) on the container. The field code number and related source details should be separately recorded in a note book.
- The testing of sample should be completed within 12 hrs. from the time of collection.

II. Water Testing Procedure

- Pour 10-20 ml. of water into the 100 ml polypropylene/titration cup.
- By observing the water in the cup, record qualitatively the appearance, odor and turbidity.
- Using the pH paper, record the pH also.

1. Appearance: Record appearance as follows:

Colorless & clear/ Brownish/ slightly brownish / Greenish/ slightly greenish/ Blackish/ slightly blackish / slightly whitish / Turbid etc.

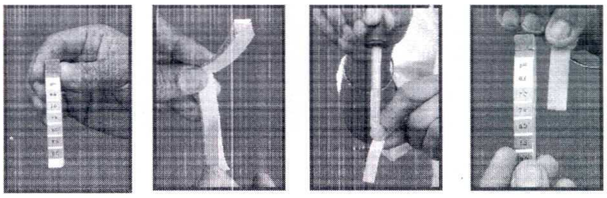
2. Odor: Record odor as follows:

None/ Soil Smell/ Algal Smell/ Objectionable Odor/ Slightly Objectionable Odor/ Rotten Egg Smell etc.

3. Turbidity: Record Turbidity as follows:

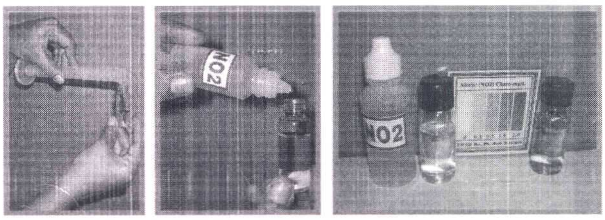
No turbidity/ slightly turbid/Moderately turbid/Highly turbid

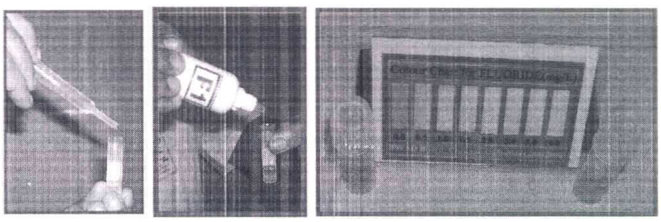
4. PH: PH booklets have been provided to measure pH value of water. Tear a portion of the PH paper and hold it by your fingers. Using the ink filler add one drop of water sample on the paper. Wait for 10 seconds. The color change taking place on the wet portion of the pH paper is observed and compared with the pH chart provided in the cover page of pH booklet. Record the pH value.



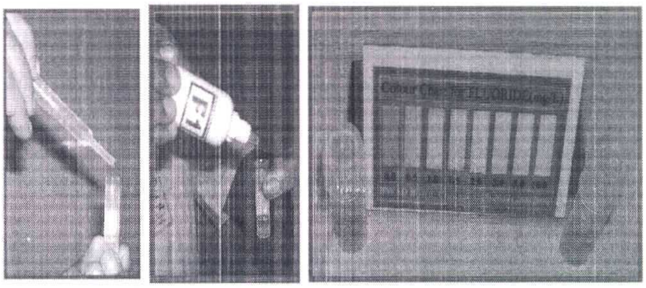
5. Alkalinity: Using the measuring cylinder, measure 20 ml of water sample and pour it into the clean titration cup. Add 5 drops of 'A1liquid. The water turns bluish green. Using the '1 mL syringe' provided in the kit, add 'A2' liquid. At the end point, the color of water changes into yellow or Orange. Record the number of divisions for which the 'A2' liquid has been consumed to reach the end point. Calculation: Alkalinity mg/L = No. of Divisions of 'A2' added x 10

6. Hardness: Using the measuring cylinder, measure 20 ml of water sample and pour it into the clean titration cup. Add 5 drops of 'H I' and then 5 drops of 'H2' liquids. The





water in the titration cup turns *Pink* in color. Using the '1 mL syringe' add 'H3' liquid in drops. At the end point, the color of water changes into *Bluish color.* Record the number of divisions for which 'H3' liquid has been consumed to reach the end point.



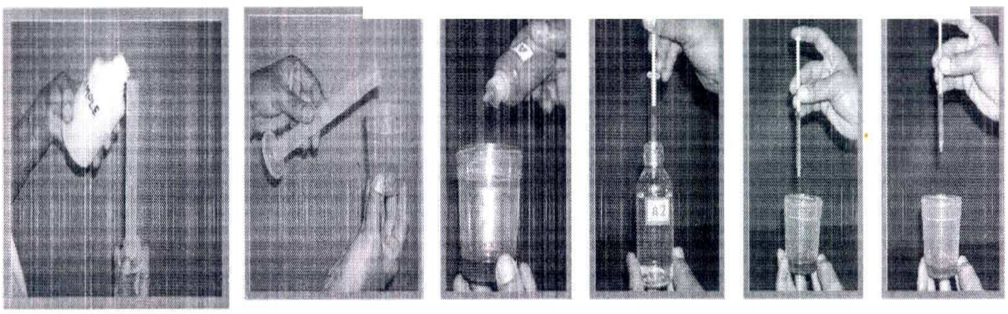
7. Chloride*:** Using the measuring cylinder, measure 20 ml of water sample and pour it into the clean titration cup. Add 5 drops of 'C1' liquid. The water turns **yellow** in color. Using the '1 mL syringe' add 'C2' liquid in drops. At the end point, the color of water changes to ***slight reddish in color. Record the number of divisions for which 'C2' liquid has been consumed to reach the end point.

Calculation: Chloride mg/L = No. of Divisions of 'C2' liquid x 10

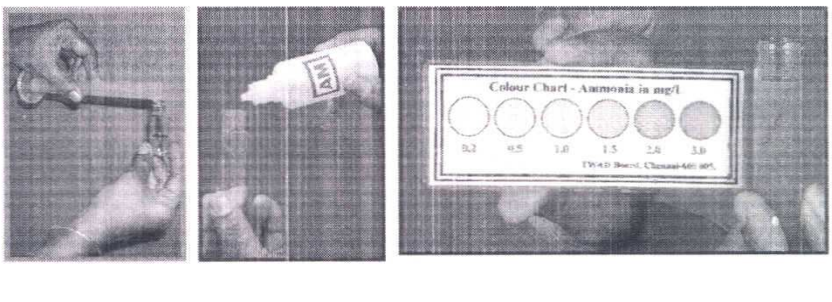
8. Total Dissolved Solids (TDS):The approximate value of TDS can be arrived at by the following calculation:

Calculation: TDS mg/L = (Alkalinity + Hardness + Chloride) x 1.2

9. Fluoride: In the 1.5 ml polypropylene tube, add 1.0 mL sample water. Add 5 drops of 'Fl' liquid. Mix. Gently. Compare the colour with "fluoride chart" provided and record the fluoride value.

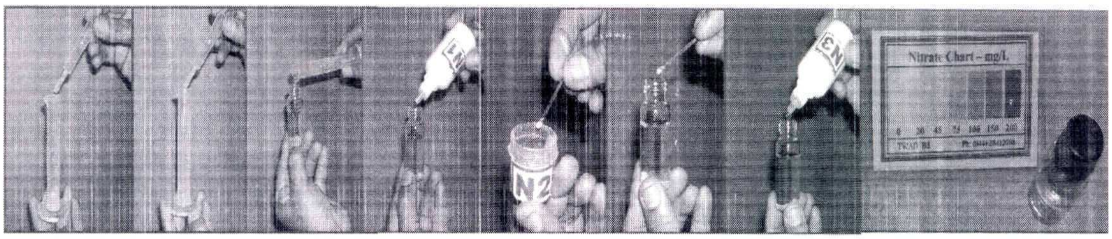


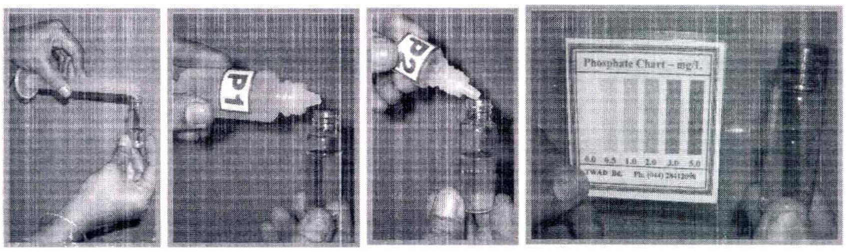
10. Ammonia: In the small glass bottle given, take 10 ml of water sample. Add 5 drops of' Amonia' liquid. Gently shake the bottle. If there is no ammonia, the color will not change. If ammonia is present, the water turns yellow, Compare the ''yellow colour developed with the **'ammonia chart'** provided and record the ammonia value.

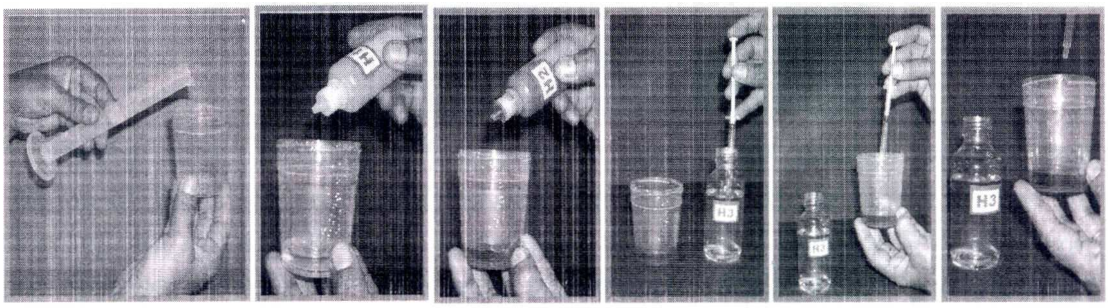


11. ***Nitrite:*** In the small glass bottle given, take 10 ml of water sample. Add 5 drops of **'N02'** liquid. Gently shake the bottle. If there is no nitrite, the color will not change. If nitrite is present, the color of water will change into pink. Compare the 'pink' color with the **'Nitrite (N02) chart'** provided and record the nitrite value

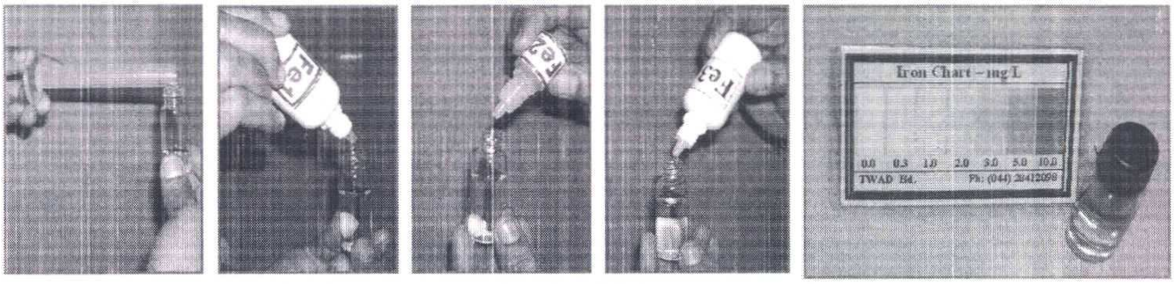
12 ***Nitrate:*** In the 10 mL measuring cylinder, take 1 mL of water sample. Add 9 mL distilled/bottled/mineral water and make up to 10 mL. Transfer this to the 10 mL glass bottle. Add 5 drops of **'NI'.** Add a small pinch of **'N2'.** Mix. Add 5 drops of **'N3'.** Wait for 2 minutes. If there is no nitrate, the color will not change. If nitrate is present, the color of water will change into pink. Compare the 'pink' color with the **'Nitrate chart'** provided and record the nitrate value.







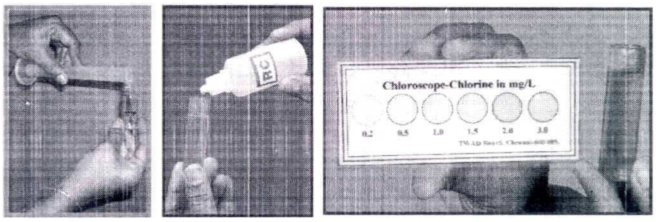
13. Iron: In the 10 mL glass bottle, take 10 ml of water sample. Add 5 drops of 'fell' liquid and then 1 drop of **'Fe2'** liquid. Mix. Add 5 drops of **'Fe3'** liquid. Mix. Wait for 2 minutes. For turbid samples wait for 5-10 minutes till a persistent colour develops. If there is no iron, the colour will not change. If iron is present, the colour of water will change into orange red. Compare the colour with the **'Iron chart'** provided and record the value.



Sample ID:

14. Phosphate: In the small glass bottle given, take 10 ml of water sample. Add 5 drops of 'PI' liquid. Gently shake the bottle. Then add 1 drop of 'P2' liquid. Again gently shake. If there is no phosphate, the color will not change. If phosphate is present, the color of water will change into blue. Compare the **'blue'** color with the **'Phosphate chart'** provided and record the phosphate value.

15. Residual Chlorine**:** In the small glass bottle given, take 10 ml of water sample. Add 5 drops of **'RC'** liquid. Slightly shake the bottle. If there is no residual chlorine, the color will not change. If residual chlorine is present, the color of water will change into **yellow**. Compare the **yellow** color with the **'chlorine chart'** provided and record the residual chlorine value.



16. ***E.Coli/Fecal Coliform:*** The test is conducted using H2S vials (H2S vials have to be procured separately from the market). The water should be added up to the mark in the H2S vial. After screwing the cap, keep the vial for 24 hours. After 24 hours observe anyone of the following changes.

i) Black color = High level of contamination
ii) Turbid &; brownish = Moderate level of contamination
iii) No change in the honey brown color = Absence of E.-Coli Fecal Coliform

III. REPORTING:

The test results should be compiled in the following report form:

Test Report

Source Details

Location and address of the source Location and address of sampling point Name of Village/Habitation, Name of Panchayat, Name of Block ,Name of District ,Type of source Type of scheme, Open well/ Bore well/ Infiltration well/ Lake/ Dam/ Hand pump/ Power pump Surface, water etc. Collected by (Name, designation & Office)

1) Appearance

2) Odor
3) Turbidity
4) Total dissolved solids (maximum)
5) pH
6) Alkalinity as CaCO3, (maxim urn)
7) Hardness as CaC03 (maximum)
8) Chloride as Cl (maximum)
9) Fluoride as F (maximum)
10) Ammonia * as NH3
11) Nitrite** as N02
12) Nitrate as NO.., (maximum)
13) Iron as Fe (maximum)
14) Phosphate** as $P0_4$
15) Residual chlorine (minimum)*** as CL2 0.2 *mg/ L*

- No guideline value prescribed; however an ammonia level of greater than 1.0 mg/L indicates pollution taking place to the source.
- No guideline value prescribed; traces of nitrite and phosphate indicate pollution.
- To ensure effective disinfection, minimum residual chlorine of 0.2 mg/L should be present.

Report: The water shall be indicated as bacteriologically and potable/non potable.

CHAPTER – 14

WATER REVENUE (BILLING & COLLECTION)

Revenue management system is an important aspect of any Water supply System as it governs the financial sustainability to it. Besides fixing a tariff structure, billing and collection of revenue play an important part.

14.1 Tariff Fixation

The water charges to be fixed by the water agency / PRIs. Taking into account the ability of the system to meet the expenditure on the following heads:

- O&M Cost (Recurring and non- recurring Establishment Cost.
- Depreciation.
- Debt Services & Doubtful Charges.
- Asset replacement fund.

Tariff structure should be revised annually increase of tariff. Periodically/ annual can also be adopted.

14.2 Categories of Consumers

Among the different categories, the domestic consumers are the privileged class of people in terms of supply of water and of consumer's collection of taxes mainly because they use water for their healthy existence. The other categories viz. commercial complexes, Hotel/restaurant, Industries/ Bulk consumers/ offices/institutions etc. largely use water and usually charged with an higher tariff. Therefore, the distribution of cost incurred on the maintenance of such system to each class of consumers including un-privileged people should be logically and appropriately determined with reference to the level of service rendered. Finally, a projected income on account of water charges should take into account the various factors stated in the paragraph above.

14.3 Methods of Water Charges

The methods of levying water charges can be any one or more of the following:

1. Metered consumption of water.
2. Non-Metered System:
    - Fixed charge per house per month (depending upon the size of the house) or per connection per month or
    - Fixed charge per family per month or per tap per month/per house or
    - Percentage of ratable value of the property.

Note: Charges for APL and BPL family may be determined separately by GP/ VWSC

14.4 Distribution of Bills to Consumer

In the case of the Multi Village Water Supply Scheme, the water agency / VWSC / agency charged for O&M will raise the bill every month to each of the Panchayat based on the bulk water meter reading. The Panchayat will pay the water charges to the agency / VWSC and in-turn will collect the water charges from the consumers

In the case of Single Village water supply scheme, the Panchayat / VWSC will collect water charges from the consumers and utilized the revenue generated for the maintenance of the scheme.

The distribution of bills in rural area can be done by operators specially authorized for this purpose or meter readers and bills can be distributed at the time of meter reading along with the receipt for previous payment if collected in cash by him for the next round.

(This option saves effort/manpower but there is delay in one complete cycle in reading and distribution of bills).

14.4.1 Payment of Bills by Consumer

The payments can be accepted at any one or more ways of the following:

- Counters at G.Ps. / VWSC office.
- At bank / banks authorized for accepting payments.
- Door to door/on the spot recovery by authorized person.
- By cheque through drop boxes.

14.4.2 Related Accounting

The billing section also carries out the accounting related to these receipts such as posting of receipts, generation of demand registers or ledgers on periodic basis. The complete accounting related to the billing may also be more efficiently carried out by the computerized system.

14.4.3 Delayed Payments

Since water is being treated as a commodity consumed the advance billing is generally not carried out. It is therefore ‘a must’ to levy penalty/interest on the delayed payments of the bills. Computerization overcomes many of the defects in the manual system, is fast and gives control on the system.

CHAPTER – 15

WATER AUDIT & LEAKAGE CONTROL

Water Audit of a water supply scheme can be defined as the assessment of the capacity of total water produced by the Water Supply Agency/VWSC and the actual quantity of water distributed throughout the area of service by the Agency/VWSC, thus leading to an estimation of the losses otherwise known as non-revenue/ un-accounted-for water (NRW/UFW) and it is the expression used for the difference between the quantity of water produced and the quantity of water billed or accounted for.

15.1 Definition of Water Audit

Water audit in a water supply system is broadly, similar in nature to energy audit and determines the amount of water lost from source of water to a distribution system including losses at users' taps due to leakages and other reasons such as theft, unauthorized or illegal withdrawals from the systems and thus, these loss costs the utility. Complete water audit plan gives a detailed profile of a water supply system including its distribution system and water users, thereby facilitating easier and effective management of the resources with improved reliability. It helps in correct diagnosis of the problems faced and suggests optimum solutions. It is also an effective tool for realistic understanding and assessment of the system's performance level, efficiency of the service and the adaptability of the system for future expansion & rectification of faults during modernization. Elements of water audit include a record of the amount of water produced, total water supplied, water delivered to metered users, water delivered to unmetered users, water losses and suggested measures to address water loss (through pinpointing & minimising leakages and other unaccounted for water losses). Generally, the following are the steps of water audit exercise:

- To conduct a water audit of the water distribution system and water accounting practices etc. and validation
- Preparation of worksheets and sample calculations for each step of the water audit
- To identify, measure and verify all water consumption and loss
- To identify and control apparent losses in metering and billing operations, and recover missed revenues
- To implement a leakage and pressure management program to control real losses, conserve water and contain costs
- Develop plans to assemble the proper resources, information and equipment to launch a sustained accountability and loss-control program
- Prepare game-plan for setting short, medium and long-term goals and estimate return on investment.

Leak detection program, a tool, help in minimizing leakages and tackling small problems before they scale-up to major ones. These programs lead to (a) reduced water losses, (b) improved reliability of supply system, (c) enhanced knowledge of the distribution system, (d) efficient use of existing supplies, (e) better safeguard to public health and property, (f) improved public relations, (g) reduced legal liability (h) reduced disruption, thereby improving level of service to customers, and (i) improved financial performance.

15.2 Application of Water Audit

Application of water audit process in domestic/ municipal sector may consist of various steps viz. water audit, interventions for water conservation/leakages/ losses control, regulatory framework & community involvement and evaluation of effectiveness of interventions undertaken.

15.2.1 Water Audit Methodology

A reliable water audit methodology was developed jointly by the American Water Works Association (AWWA) and International Water Association (IWA) in year 2000. The water balance of this methodology is given below and shows schematically the various components in which water volumes (typically one year) are tracked.

System Input Volume (corrected for known errors)	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption (including water exported)	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Customer Metering Inaccuracies	
			Data Handling Errors	
		Real Losses	Leakage on Transmission and Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	

The water balance tracks – from left to right – how a water agency supplies water volumes from source to customer and provides the format for the agency to quantify amounts of billed and lost water. Fundamental to the AWWA/IWA Water Audit Methodology is the distinction that treated drinking water goes to two places: authorized consumption by consumers (its intended use) and a portion to losses (through inefficiencies). Within the component of losses, two broad types exist:

Apparent Losses are the "paper" losses that occur in utility operations due to customer meter inaccuracies, billing system data errors and unauthorized consumption. In other words, this is the water that is consumed but is not properly measured, accounted or paid for. These losses cost utilities revenue and distort data on customer consumption patterns.

Real Losses are the physical losses of water from the distribution system, including leakage and storage overflows. These losses inflate the water utility's production costs and stress water resources since they represent water that is extracted and treated, yet never reaches beneficial use.

15.2.2 Planning and Preparation

Planning and preparation shall include the data collection element and the preparation of sketch plans for the distribution centers and other locations for the installation of the flow-meters. Also included within this shall be the confirmation of flow rates for the bulk meter locations which has been carried out by the use of portable ultrasonic flow meters.

(a) Preliminary Data Collection

The water distribution drawings are to be studied and updated. The number of service connections is to be obtained and in the drawings of the roads the exact locations of service connections marked. The district and sub-district boundaries are suitably fixed taking into consideration the number of service connections, length of mains, and pressure points in the main. The exact locations of valves, hydrants with their sizes should be noted on the drawings.

The above activities will help in planning the conduct of sounding of the system for leaks or for fixing locations for conduct of pressure testing in intermittent water supply system before commencement of leak detection work or for measuring pressure and leak flow in the continuous water supply system.

(b) Pipe Location Survey

Electronic pipe locators can be used during survey. These instruments work on the principle of Electromagnetic signal propagation. It consists of a battery operated transmitter and a cordless receiver unit to pick up the signals of pre-set frequency. There are various models to choose from. Valve locators are metal detectors that are available which can be used to locate buried valves.

15.2.3 Verification and Updating Of Maps

Mapping and inventory of pipes and fittings in the water supply system: If the updated maps are available and bulk meters are in position, network survey can be taken up as a first step. Otherwise maps have to be prepared and bulk meters fixed. The agency should set up routine procedures for preparing and updating maps and inventory of pipes, valves and consumer connections. The maps shall be exchanged with other public utilities and also contain information on other utility services like electricity, communications etc.

15.2.4 Installation of Bulk Meters

The major activity during the overall water audit will be bulk meter installation at those points on the distribution network where water enters the system. It is expected that bulk meters will be required at the following locations:

- All major system points (e.g. raw water inlet, clear water outlet, main distribution branch, SRs etc.).
- All tube wells/ sources which supply the system directly.
- Major transfer mains which are expressly required for audit.
- At distribution centers, the most appropriate meter position is on the outlet pipe from the service reservoir. Installation of a meter at this point will allow measurement of flows into the system not only if supplies are coming from the service reservoir but also if they are being pumped directly from the clear water reservoir (CWR)
- The size of the meter can be determined by flow of water, size of pipe line and Meter manufacturer's specifications having consideration of the following :
    - Number of properties served.
    - Per capita consumption (liters/person/day).
    - Population density.
    - Meter manufacturer's specifications

- Hours of supply-Meter sizes must be decided according to current supply hours or size of the pipe. Future changes to system operation may require the substitution of some bulk meters with those of a smaller size, due to reductions in flow over longer supply hours.

It is expected that bulk meters installed in locations where supply is rationed will tend to over-read. This is because when supplies are turned on, the air present in the pipes can cause the meter to spin. This problem may be overcome through the use of combined pressure and flow loggers. Flow through the meter will be recorded in the normal way. However, analysis of the pressure and flow plots together will enable the identification of that period of time when a flow is recorded at zero pressure. This time should correspond to the period when the meter is spinning, and the true flow through the meter over a period of time can therefore be calculated.

15.2.5 Monitoring Of the Production System

The assessment of the leakage rates through the various features of the water supply system should be undertaken. These will include raw water transmission system, reservoirs, treatment plant, clear-water transmission system, inter-zone transmission system, tube wells/ sources of water supply.

15.2.6 Transmission System

The methodology adopted to make an assessment of the level of losses in the transmission system is to install insertion probes/bulk meter at both ends of each section of main being monitored, thus monitoring both the inflow and outflow of the section. This monitoring should be done for a minimum period of 7 days. The difference of inflow and outflow will indicate the losses in the transmission main. The advantage of this method is that the trunk main need not be taken out of service.

Another way to measure leakage is to close two valves on the main. 25mm tapping are made on either side of the upstream valve and a small semi-positive displacement flow meter is connected between the two tapings. Flow through this meter will indicate the leakage in the main between the two closed valves. It must be ensured that the downstream valve is leak proof.
The approximate position of any leakage measured can be determined by the successive closing of sluice valves along the main in the manner of a step test

15.2.7 Reservoirs

To reduce or avoid any leakage or consequent contamination in reservoirs, the reservoirs should be periodically tested for water tightness, drained, cleaned, washed down and visually inspected. The losses in water storage structures can be monitored for a particular period noticing the change in the level gauges when the structure is out of use i.e. there is no inflow and outflow of water during this monitoring period.
The most reliable method for measurement of leakage from a service reservoir is to fill it to full level and isolate it from supply and to measure change in level over suitable time period. Suitable equipment to measure reservoir levels could be chosen like:

- Sight gauges
- Water level sensors (as per manufacturer’s instruction)
- Float gauges
- Submersible pressure & level transducers (as per manufacturer’s instruction).

15.2.8 Treatment Plant

The losses in treatment plant can be monitored by measuring the inflow into the plant and out flow from the plant with the help of mechanical electronic flow recorders. The difference of inflow and outflow for the monitoring period will indicate the water losses in the plant. In case the loss is more than the design limit, further investigation should be carried out for remedial measures.

15.2.9 Tube Wells

In conjunction with the programme of bulk meter installation is the operation to monitor the approximate yield from the tube wells. This exercise can be carried out by the installation of semi-permanent meters to the tube wells on a bypass arrangement similar to that for the bulk meters. This can be affected utilizing the smaller diameter bulk meters. Insertion probes or the portable ultrasonic flow meters will be used for measurement of flows on the common feeder mains.

15.2.10 Monitoring of Distribution System

Distribution system comprises of service reservoirs, distribution mains & distribution lines. Metered, unmetered (flat rate), public stand posts, hydrants, illegal connections
Water audit of the distribution system consists of:

- Monitoring of flow of water from the distribution point into the distribution system.
- Consumer meter sampling i.e. water monitoring Area (WMA) and estimating metered use by consumers, if any.
- Estimating losses in the appurtenances and distribution pipe line network including consumer service lines.

15.2.10.1 Monitoring Flow In to The Distribution System

A bulk meter of the appropriate type and size is installed at the outlet pipe of the service reservoir or at the point where the feeding line to the area branches off from the trunk main. If water from the WMA (water monitoring Area) flows out into another zone a valve or meter is to be installed at this outlet point.

15.2.10.2 Customer Meter Sampling

Water audit is a continuous process. However, consumers' meter sampling can be done on yearly basis by Review of all existing bulk and major consumers for revenue. A co-relation between the production/power consumed in the factory viz-a-viz water consumption can be evaluated by:

- Sampling of 10% of all bulk and major consumers.
- Sampling of 10% of small or domestic consumers.
- Series meter testing of large meters suitably according to standard, calibrated meter
- Testing of 1% large and 1% domestic meters.
- Estimating consumption at a representative 5% sample of Public Stand Posts (PSP) and unmetered connections by carrying out site measurements.

All non-functioning and broken meters in the sample areas will be replaced and all meters may be read over a week. This information will be brought together with information derived from the workshop and series testing in order to estimate the average water delivered and correction factors for consumer meters. These factors can then be extrapolated to the rest of the customer meter database

15.2.10.3 Losses in Customer Service Lines and Appurtenances

Losses can be calculated by deducting the following from the total quantity by the following:

- Metered consumption.
- Illegal connection consumption (assuming metered use).
- PSP use.
- Free supply, use in public toilets, parks etc.

15.2.11 Analysis

The information of the results of monitoring the distribution system together with the results of the bulk metering exercise will be consolidated and brought together to produce the water balance report and the overall water audit report. These results may be interpreted in financial terms. Further exercise will be done to classify the water consumed/wasted/lost in financial terms with relation to the current and future level of water charges. This exercise will be carried out as a result of the field tests and the review of existing records forming part of the overall water audit.

This water audit will provide sufficiently, accurate area wise losses to priorities the area into3 categories viz.

- Areas that need immediate leak detection and repair.
- Areas that need levels of losses (UFW) to be closely monitored.
- Areas that appear to need no further work at the current time.

It is recommended that cursory investigation should be carried out in the areas that appear to have the least levels of losses (UFW), locating any major leaks, followed by the leak repairs would reduce the losses (UFW) levels further. After water audit of few cities/ villages, it has been reported that the components of UFW may generally be as follows:

- Leakage (physical losses) 35 to 50%
- Meter under-registration 10 to 15%
- Illegal/unmetered connections 3.5 to 6%
- Public use 1.5 to 3.5%

15.3 Leakage Control

The overall objective of leakage control is to diagnose how water loss is caused and to formulate and implement action to reduce it to technically and economically acceptable minimum. Specifically the objectives are:

- To reduce losses to an acceptable minimum.
- To meet additional demands with water made available from reduced losses thereby saving in cost of additional production and distribution.
- To give consumer satisfaction.
- To augment revenue from the sale of water saved.

(a) WATER LOSSES

The water losses can be termed into two categories.

- Physical losses (Technical losses)
- Non-physical losses (Non-technical losses/Commercial losses)

(i) PHYSICAL LOSSES (TECHNICAL LOSSES)

This is mainly due to leakage of water in the network and comprises of physical losses from pipes, joints & fittings, reservoirs & overflows of reservoirs & sumps.

(ii) NON-PHYSICAL LOSSES (NON-TECHNICAL LOSSES)

Theft of water through illegal, already disconnected connections, under-billing either deliberately or through defective meters, water wasted by consumer through open or leaky taps, errors in estimating flat rate consumption, public stand posts and hydrants.

(b) LEAKAGE DETECTION AND MONITORING

The major activities in the leak detection work in the distribution system:
• Preliminary data collection and planning.
• Pipe location and survey.
• Assessment of pressure and flows.
• Locating the leaks.

• Assessment of leakage.

15.4 Benefits of Water Audit and Leak Detection

Water audits and leak detection programmes can achieve substantial benefits, including the following:

(a) Reduced Water Losses

Water audit and leak detection are the necessary first steps in a leak repair programme.

Repairing the leak will save money for the utility, including reduced power costs to deliver water and reduced chemical costs to treat water.

(***b) Financial Improvement***

A water audit and leak detection programme can increase revenues from customers who have been undercharged, lower the total cost of whole sale supplies and reduce treatment and pumping costs.

(c) Increased Knowledge of the Distribution System

During a water audit, distribution personnel become familiar with the distribution system, including the location of main and valves. This familiarity helps the utility to respond to emergencies such as main breaks.

(d)More Efficient Use of Existing Supplies

Reducing water losses helps in stretching existing supplies to meet increased needs. This could help defer the construction of new water facilities, such as new source, reservoir or treatment plants.

(e) Safeguarding Public Health and Property

Improved maintenance of a water distribution system helps to reduce the likelihood of property damage and safeguards public health and safety.

(f) Improved Public Relation

The public appreciates maintenance of the water supply system. Field teams doing the water audit and leak detection or repair and maintenance work provide visual assurance that the system is being maintained.

(g) Reduced Legal Liability

By protecting public property and health and providing detailed information about the distribution system, water audit and leaks detection help to protect the utility from expensive law sue.

CHAPTER – 16

ENERGY AUDIT & CONSERVATION OF ENERGY

16.1 Introduction

Energy is very scarce and short supply commodity particularly in most of the states in the country and its cost is spirally increasing day-by-day. Generally pumping installations consume huge amount of energy wherein proportion of energy cost can be as high as 40 to 70% and even more of overall cost of operation and maintenance of water works. Need for conservation of energy, therefore cannot be ignored. All possible steps need to be identified and adopted to conserve energy and reduce energy consumption, and cost so that water tariff can be kept as low as possible and gap between high cost of production of water and price affordable by consumers can be reduce.

Some adverse scenarios in energy aspects as follows are quite common in pumping installations:

- Energy consumption is higher than optimum value due to reduction in efficiency of pumps.
- Operating point of the pump is away from best efficiency point (b.e.p.).
- Energy is wasted due to increase in head loss in pumping system e.g. clogging of strainer, encrustation in column pipes, and encrustation in pumping main.
- Selection of uneconomical diameter of sluice valve, butterfly valve, reflux valve, column pipe, drop pipe etc. in pumping installations.
- Energy wastage due to operation of electrical equipment's at low voltage and/or low power factor.

Such inefficient operation and wastage of energy need to be avoided to cut down energy cost. It is therefore, necessary to identify all such shortcomings and causes which can be Strategy as follows, therefore need to be adopted in management of energy

- Conduct thorough and in-depth energy audit covering analysis and evaluation of all equipment, operations and system components which have bearings on energy consumption, and identifying scope for reduction in energy cost.
- Implement measures for conservation of energy.
- Energy audit as implied is auditing of billed energy consumption and how the energy is consumed by various units, and sub-units in the installation and whether there is any wastage due to poor efficiency, higher hydraulic or power losses etc. and identification of actions for remedy and correction.
- In respect of the sources like, infiltration wells, open wells, collector wells, the working head can be decided based upon the suction head, delivery head, frictional loss with reference to the pipe material used and other losses.
- In respect of bore well sources, while submersible pump sets are used, the pump suction depth may be fixed with reference to the final spring achieved during drilling.
- Working of head of pumps shall be made in conservative way.
- If head of pump is excess of actual requirement then pump impeller shall be trimmed as per affinity law.
- In large pumping station pumps with variable frequency shall be used.
- With low power factor loads, the current flowing through electrical system components is higher than necessary to do the required work. In order to achieve power factor greater than 0.9 power capacitors of required capacity shell be installed on all the installation of Pumping machinery.

- Electric motors usually run at a constant speed, but a variable frequency (speed) Drive (VFD) allows the motor's energy output to match the required load. This achieves energy savings depending on how the motor is used. When we use a control valve or regulator, we lose energy because the pumps are always operated at high speed.

16.2. Scope of Energy Audit

Energy audit includes following actions, steps and processes:

1) Conducting in depth energy audit by systematic process of accounting and reconciliation between the following:
    a. Actual energy consumption.
    b. Calculated energy consumption taking into account rated efficiency and power losses in all energy utilizing equipment and power transmission system i.e.
2) Conducting performance test of pumps and electrical equipment if the difference between actual energy consumption and calculated energy consumption is significant and taking follow up action on conclusions drawn from the tests.
3) Taking up discharge test at rated head if test at Sr. No. (ii) is not being taken.
4) Identifying the equipment, operational aspects and characteristic of power supply causing inefficient functioning, wastage of energy, increase in hydraulic or power losses etc. and evaluating increase in energy cost or wastage of energy
5) Identifying solutions and actions necessary to correct the shortcomings and lacunas in (IV) and evaluating cost of the solutions.
6) Carrying out economic analysis of costs involved in (iv) and (v) above and drawing conclusions whether rectification is economical or otherwise.
7) Checking whether operating point is near best efficiency point and whether any improvement is possible.
8) Verification of penalties if any, levied by power supply authorities e.g. penalty for poor power factor, penalty for exceeding contract demand. Broad review of following points for future guidance or long term measure:
    - C-value or f-value of transmission main.
    - Diameter of transmission main provided.
    - Specified duty point for pump and operating range.
    - Suitability of pump for the duty conditions and situation in general and specifically from efficiency aspects.
    - Suitability of ratings and sizes of motor, cable, transformer and other electrical appliances for the load.

16.2.1 Study and Verification of Energy Consumption

a) All Pumps Similar (Identical):

i. Examine few electric bills in immediate past and calculate total number of days, total kWh consumed and average daily kWh [e.g. in an installation with 3 numbers working and 2 numbers standby if bill period is 61 days, total consumption 5,49,000 kWh, then average daily consumption shall be 9000 kWh].

ii. Examine log books of pumping operation for the subject period, calculate total pump - hours of individual pump sets, total pump hours over the period and average daily pump hours [Thus in the above example, pump hours of individual pump sets are: 1(839), 2(800), 3(700), 4(350) and 5(300) then as total hours are2989 pump-hours, daily pump hours shall be 2989 ÷ 61 = 49 pump hours. Average daily operations are: 2 numbers of pumps working for 11 hours and 3 numbers of pumps working for 9 hours].

iii. From (i) and (ii) above, calculate mean system kW drawn per pump set [In the example, mean system power drawn per pump set = 9000 / 49 i.e. 183.67 kW].

iv. From (i), (ii) and (iii) above, calculate cumulative system kW for minimum and maximum number of pumps simultaneously operated. [In the example, cumulative system kW drawn for 2 numbers of pumps and 3 numbers of pumps operating shall be 183.67 x 2 = 367.34 kW and 183.67 x 3 = 551.01 kW respectively].

v. Depending on efficiency of transformer at load factors corresponding to different cumulative kW, calculate output of transformer for loads of different combinations of pumps. [In the example, if transformer efficiencies are 0.97 and 0.975 for load factor corresponding to 367.34 kW and 551.01 kW respectively, then outputs of transformer for the loads shall be 367.34 x 0.97 i.e. 356.32 kW and 551.01 x 0.975 i.e. 537.23 kW respectively.

vi. The outputs of transformer, for all practical purpose can be considered as cumulative inputs to motors for the combinations of different number of pumps working simultaneously. Cable losses, being negligible, can be ignored.

vii. Cumulative input to motors divided by number of pump sets operating in the combination shall give average input to motor (In the example, average input to motor shall be 356.32 ÷ 2 i.e. 178.16 kW each for 2 pumps working and 537.23÷ 3 i.e. 179.09 kW each for 3 pumps working simultaneously.

viii. Depending on efficiency of motor at the load factor, calculate average input to pump. [In the example, if motor efficiency is 0.86, average input to pump shall be 178.16 x 0.86 i.e. 153.22 kW and 179.07 x 0.86 i.e. 154.0 kW].

ix. Simulate hydraulic conditions for combination of two numbers of pumps and three numbers of pumps operating simultaneously and take separate observations of suction head and delivery head by means of calibrated vacuum and pressure gauges and/or water level in sump/well by operating normal number of pumps i.e. 2 number and 3 numbers of pumps in this case and calculate total head on the pumps for each operating condition. The WL in the sump or well shall be maintained at normal mean water level calculated from observations recorded in log book during the chosen bill period.

x. Next operate each pump at the total head for each operating condition by throttling delivery valve and generating required head. Calculate average input to the pump for each operating condition by taking appropriate pump efficiency as per characteristic curves.

xi. If difference between average inputs to pumps as per (viii) and (x) for different working combinations are within 5% - 7%, the performance can be concluded as satisfactory and energy efficient.

xii. If the difference is beyond limit, detailed investigation for reduction in efficiency of the pump is necessary.

xiii. Full performance test for each pump shall be conducted as per procedure

xiv. If for some reason, the performance test is not undertaken, discharge test of each single pump at rated head generated by throttling delivery valve need to be carried out.

xv. If actual discharge is within 4% - 6% of rated discharge, the results are deemed as satisfactory.

xvi. Test for efficiency of pumping machinery after each repairing shall be taken. If necessary inefficient machinery should be replaced by energy efficient / star ratted machinery.

(b) Dissimilar Pumps

Procedures for energy audit for dissimilar pumps can be similar to that specified for identical pumps except for adjustment for different discharge as follows:

- Maximum discharge pump may be considered as 1(one) pump-unit.
- Pump with lesser discharge can be considered as fraction pump-unit as ratio of its discharge to maximum discharge pump. [In the above example, if discharges of 3 pumps are 150, 150 and 100 liters per second respectively, then number of pump-units shall be respectively 1, 1 and 0.667. Accordingly the number of pumps and pump-hours in various steps shall be considered as discussed for the case of all similar pumps.

16.3 Measures for Conservation Of Energy

Measures for conservation of energy in water pumping installation can be broadly classified as follows:

(a)Routine Measures

The measures can be routinely adopted in day to day operation and maintenance.

(b)Periodical Measures

Due to wear and encrustation during prolonged operation, volumetric efficiency and hydraulic efficiency of pumps reduce. By adopting these measures, efficiency can be nearly restored. These measures can be taken up during overhaul of pump or planned special repairs.

(c)Selection Aspects

If during selection phase, the equipment i.e. pumps, piping, valves etc. are selected for optimum efficiency and diameter, considerable reduction in energy cost can be achieved.

(d) Measures for System Improvement

By improving system so as to reduce hydraulic losses or utilized available head hydraulic potentials, energy conservation can be achieved.

Use of water harvesting through storages as supplementary to the main water supply system, saves lot of energy

16.3.1 Routine Measures

(a)Improving Power Factor

Generally as per guidelines of power supply authority, average power factor (PF) of more than 0.9 is to be maintained in electrical installations. The power factor can be improved to level of 0.97 or 0.98 without adverse effect on motors. Further discussion shows that considerable saving in power cost can be achieved if PF is improved.

The low power factor may attract penalty by respective power supply authorities.

b)Operation of Working and Standby

Transformers As regards operation of working and standby transformers, either of two practices as below is followed:

i) One transformer on full load and second transformer on no-load but, charged.

ii) Both transformers on part load.

c) Voltage Improvement by Voltage Stabilizer or at Transformer by OLTC

If motor is operated at low voltage, the current drawn increases, resulting in increased copper losses and consequent energy losses.

d)Reducing Static Head (Suction Side)

A study shows that energy can be saved if operating head on any pump is reduced. This can be achieved by reducing static head on pumps at suction end or discharging end or both. One methodology to reduce static head on pumps installed on sump (not on well on river/ canal/lake source) is by maintaining WL at or marginally below FSL, say, between FSL to (FSL - 0.5 m) by operational control as discussed below.

1. Installation where inflow is directly by conduit from dam

2. In such installations, the WL in sump can be easily maintained at FSL or slightly below, say, FSL to (FSL - 0.5m) by regulating valve on inlet to sump.
3. Other installations

(e)Keeping Strainer or Foot Valve Clean and Silt Free

Floating matters, debris, vegetation, plastics, gunny bags etc. in raw water clog the strainer or foot valve creating high head loss due to which the pump operates at much higher head and consequently discharge of the pump reduces. Such operation results in:

- Operation at lower efficiency as operating point is changed. Thus, operation is energy wise inefficient.
- Discharge of the pump reduces. If the strainer/foot valve is considerably clogged, discharge can reduce to the extent of 50% or so.
- Due to very high head loss in strainer/foot valve which is on suction side of the pump,

f)Preventing Throttling of Pump

g)Replacement of existing Mercury Vapour Lamps & Sodium Vapour Lamps by LED or solar lamps

16.3.2 Periodical Measures

a)Restoring Wearing Ring Clearance

Due to wear of wearing rings, the clearance between wearing ring increases causing considerable reduction in discharge and efficiency. Reduction in discharge up to 15-20% are observed in some cases. If wearing rings are replaced, the discharge improves to almost original value.

Initial leakage through wearing rings is of the order of 1 to 2% of discharge of the pump. Due to operation, wearing rings wear out causing increase in clearance which increases leakage loss and results in consequent reduction in effective discharge of the pump. A study shows that even though discharge is reduced, power reduction is very marginal and as such the pump operates at lower efficiency. Reduction in discharge up to 15% to 20% is not uncommon. Thus the pumps have to be operated for more number of hours causing increase in energy cost.

(b) Reducing Disk Friction Losses Disk friction losses in pump accounts for about 5% of power consumed by the pump. The A study shows that if surfaces of the impeller and casing are rough, the disk friction losses increase. If casing is painted and impeller is polished, disk friction losses can be reduced by 20% to 40% of normal loss. Thus as disk friction loss is about 5% of power required by the pump, overall saving in power consumption will be 1% to 2%. For large pump the saving can be very high.

c) Scrapping down Encrustation inside Column Pipes

Due to operation over prolonged period, encrustation or scaling inside the column pipe develops causing reduction in inside diameter and making surface rough. Both phenomenon cause increase in friction losses. If scrapping of encrustation is carried out whenever column pipes are dismantled energy losses can be avoided.

16.3.3 Selection Aspects

a) Selection of star rating motor pump

Now a days, three star/five star rating pump sets are available in the market, which can save 10-15 & of power, can be used in place of normal pumping machinery.

b)Optimum Pump Efficiency

Optimum efficiency of pump can be ensured by appropriate selection such that specific speed is optimum. Specific speed

b) *Optimisation of Pipe appurtenance-*

Sluice Valve/Butterfly Valve and Non-Return Valve on Pump Delivery 'K' values of sluice valve and non-return valve are 0.35 and 2.50 respectively which amount to combined 'K' valve of 2.85. Due to very high 'K' value, head loss through these valves is significant and therefore, it is necessary to have optimum size of valves.

d) *Delivery Pipe for Submersible Pump*

As delivery pipe for submersible pump is comparatively long and therefore, head loss in delivery pipe is considerable, it is of importance to select proper diameter. Optimum design velocity is around 1.1 - 1.5 m/s. However, pipe diameter should not be less than 50 mm

16.3.4 ESCO Concept for Energy Audit

Some State Govt.'s are implementing a new concept of Energy Saving Companies (ESCOS), as pilot project for undertaking Energy auditing. According to this concept these energy Saving Companies who are willing to put in their money will be invited to take up and complete energy saving measures and the at least cost saving will be shared by the local bodies/ Government agencies and ESCO. The local bodies/ Government Agency who follow this model will gain by saving the energy cost without investing in the project.
Energy saving – a scheme specific example.
Energy audit was carried out in the CWSS to Coimbatore Local planning and Rural areas with Pillar Reservoir as source and the following energy saving measures were under taken.

- Introduction of power capacitors closer to the starters instead of at the panel board. Coro- coating of impellers of the pumps
- Introduction of Variable Frequency Drive (VFD) at the pumping station where trolling of pump discharge is required.
- Introduction of online flow monitoring and accounting system (Telemetry/. SCADA)

The above measures were implemented and the total savings achieved is indicated below:

Location	Activity	Date carried out	Average energy cost / month		Savings/ month
			Before	After	
Pilur	Shifting of capacitor	Oct.06	26,49,254	25,09,905	1,39,349
Pillur Velliangadu	Coro– coating of pump impellers	Oct. 02 to Jan. 03	29,32,505`	26,50,300	2,82,205

CHAPTER – 17
LIFE CYCLE COST & SERVICE DELIVERY APPROACH

17.1. Life Cycle Cost Approach

Life cycle cost (LCC)represents the aggregate costs of ensuring delivery adequate, equitable and sustainable drinking Water Sanitation and Hygiene services to a population in a determined geographical area .These cost includes not only the cost of constructing system but also what it costs to maintain them in the short and long term, to replace, extend and enhance them as well as the indirect support cost of the enabling environment , viz. capacity building, planning and monitoring at both District and state level, not just for a few years, but at least for project design period or more.

The delivery of sustainable services requires that financial support system are in place to ensure that infrastructure can be renewed and replaced at the end of its useful life, and to deliver timely breakdown repairs, along with the capacity to extend delivery system and improve service delivery in response to changes in demand .Thus the 'life cycle approach is enough flexible to build, sustain, repair and renew a water (sanitation) system through the whole of its cycle of use.

The life cycle cost Approach (LCCA) seeks to raise awareness of the importance of LCC in achieving adequate, equitable and sustainable drinking water services, to make reliable cost information readily available and to mainstream the use of LCC in drinking water governance process at every level.

Life cycle cost approach is a step towards increasing the efficiency and effectiveness of investment in the WASH sector, to find a balance between the allocations of money for new infrastructure to increase coverage, and the allocation for major repair and rehabilitation of drinking water infrastructure to maintain a basic level of service.

The LCCA can be a useful for monitoring and costing sustainable WASAH services by assessing cost and comparing them against levels of service provided, how can we achieve the most by least spending.

17.1.1 Cost Components

The following cost component is generally;

1. Capital expenditure- hardware and software (Cap Ex)-includes the Concrete structures, Pumps, pipes, filtration units etc.to develop and extend the service.
2. Operating and Minor Maintenance Expenditure (OpEx)-Requirement for recurring regular, ongoing expenditure viz.labor, fuel, chemicals, material and purchases of any bulk water (5% to 20 % of capital investments).
3. Capital Maintenance Expenditure (CapManEx)-Expenditure on asset renewal, replacement and rehabilitation covers the work other than routine maintenance to repair and replacement in order to keep system running.
4. Cost of capital (Co'C) -Cost of Financing a Program or Project i.e. the cost assessing the funds needed to construct a system.
5. Expenditure on direct support (ExpDs)-it includes expenditure on both pre-and post-construction support activities.
6. Expenditure on indirect support (ExpIDS)-include the macro-level support ,capacity building, policy, planning and monitoring that contribute to the sector working capacity and regulation but are not particular to any programme or project.
7. Total Expenditure (TotEx)-determined using fixed assets accounting to aggregate the cost components described above

17.2 Service Delivery Approach

A service delivery approach is a concept for ensuring the sustainability of rural drinking water services. It seeks to improve on the record of the project –and implementation-focused approaches, in which users initially enjoy good service after constriction of drinking water supply system. But without support and proper asset management, the system quickly starts deteriorate until it collapses completely. At some time in the future a new system is built, typically by another agency.

In a service delivery approach, a water system is maintained indefinitely through a planned process of low intensity administration and management, with occasional capital-intensive intervention to upgrade the service level and to replace the infrastructure at the end of its useful life

A service delivery approach aims to provide long term services. Thus it goes hand in hand with life cycle costing, which accounts for cost over the entire life cycle of a service –both the initial engineering and construction of infrastructure and the software (capacity building ,institutional support ,financial planning)and maintenance required to sustain a certain level of drinking water services delivery in to the indefinite future. A service delivery approach requires defining roles and responsibilities for multiple actors working at different levels and improving coordination and harmonization among their activities

17.3 Why the Service Delivery Approach matters

In the early 1990s, an estimated 30% to40% of rural water supply system in developing countries including India was not working. This failure rate has not changed much, and studies indicate that a similar proportion of system, particularly hand pumps, either do not function at all or are working at suboptimal levels. Because of the failure on service delivery, the following problems have emerged:

- Throughout the World, at a point of time, approximately one in three Water supply system is not working Hundreds of millions of dollars has been wasted on infrastructure investment ,and millions of people have returned to fetching water from distant ,unsafe sources to the detriment of their health ,education and livelihoods
- True life -cycle cost are poorly understood and are not planned for, resulting in extended down time or the complete abandonment of systems ,while funding for major repairs or replacements is sought.
- Community management – the predominant service delivery model-has limitations and is inherently unsuited to scaling up.
- Donors and NGOs have often taken their own approaches to implementing rural water supply projects, building system without ensuring the institutional structures needed to sustain long term services. Rural water sector remains week, despite significant investment.

CHAPTER-18

Community Participation and Compliant Redressal System in O&M of Water Supply Schemes

18.1 Institutional roles and responsibilities

It is clear those local governments/PRIs and communities cannot succeed on their own. They need to be given clear-cut roles and responsibilities. These include Panchayat Raj institutions, line departments, training institutions, and the local private sector and NGOs. Before the NRDWP Support fund was created there was no provision for regular funding of Support activities under the main programme. It is now possible to take up capacity building programmes on redefining roles and responsibilities using these funds.

18.1.1 Actions Plan

- States should introduce standard operating procedures for O&M of hand pumps and piped water supplies and should identify and assign key functions to the appropriate mechanism for O & M through GPs/VWSCs or person such as the hand pump caretaker or operator or civil societies/trusted NGO.
- Timely transfer of O&M, State plan and Finance Commission funds is necessary to enable GPs to operate and maintain schemes without service breaks. Wherever it is not yet adopted NRDWP (O&M) and other funds necessary for drinking water supply to GPs should be transferred electronically to GP accounts.
- For hand pumps, the GP or VWSC needs to be provided access to spare parts and trained mechanics by the DWSMs for regular preventative maintenance of all hand pumps in the GP.
- For piped water supply systems with community stand posts and/or household connections, the DWSM/BRC and VWSC needs to make sure that community based operators receive training to gain the technical and financial skills to do the job.
- Block or District Panchayats and Joint Scheme Level Committees consisting of heads of VWSCs/GPs benefited by the scheme are responsible for overseeing multi-village schemes.
- In multi-village schemes or large water grids, bulk supply should be managed/operated by PHEDs/Boards or private operators with tariffs set by the State government/PRIs/water resources regulator.
- Customer consultation and grievance redressal mechanisms should be established such as provision of a toll free number, call centers, mobile SMSs, linking GPs and engineers electronically with Block and District IMIS systems, citizen report cards and community score cards.
- Initially all bulk water supply and retail water supply to commercial, industrial establishments and private institutions should be installed with volumetric metering. Gradually all household connections should be metered.
- Water audits, energy audits and measurement of Unaccounted for Water (UfW) and Non-Revenue Water (NRW) should be introduced & institutionalized for bulk and distribution piped water supplies.
- Automated pumps should be installed, wherever feasible, in piped water supply schemes to ensure reliable water supply and reduce operator workload.

- Standard operating procedures for coping with natural disasters, including for drought and floods, will be laid down on the lines of SOP published by ministry of Drinking Water and Sanitation and disseminated through training and awareness generation programmes.
- GPs/VWSCs must also prepare and implement service improvement plans for prioritizing repairs, replacement and expansion of source and system parts.
- Zilla Panchayats should have a Water Supply O & M Wing to provide continuous technical support to GPs in managing their water supply schemes.
- Federation of VWSCs can also take up major maintenance, renovation and modernization of rural water supply schemes with technical and staff support from PHEDs/Corporations/Boards. They can reduce costs by engaging local technicians trained in vocational institutes or industrial training institutes (ITIs) to provide services round the year. This would significantly mitigate deficiencies of technical capacity and manpower availability at block and lower levels.

Multi village water supply schemes are formulated to provide water supply to many villages / habitations in many panchayats which in turn will be covered by various panchayat unions / blocks spreading over many districts. In these type of schemes, the source, pumping stations, treatment plant, pumping main and branch pumping main etc. are common components intended to deliver water to various villages / habitations of various village pancayats covered in the CWSS though the OHT located in those habitations/ villages.

Wherever necessary urban local bodies like Municipalities /Town Panchayat who have contributed their proportionate cost will also be included in these scheme for maintenance up to the level of OHT located in these Urban local bodies. For these urban local bodies also, the same source, pumping main, branch pumping main etc. will serve as common components and these schemes are called as combined water supply schemes instead of calling them as multi village schemes since urban local bodies are also included in them.

In many of the schemes, the number of villages / Panchayat covered may run into several hundreds and even thousand in some cases. Therefore operation and maintenance of the scheme including collection of water tariff from all households by one single entity may not be possible. That is why it is considered prudent to entrust the responsibility of operation of maintenance of common components to the PHE Dept/Boards who as well executed the scheme and the village specify components such as OHT, Distribution system etc. will be under the custody of the respective village Panchayat / local body.

The following may be the operational arrangements.

1. The EE/ Maint.Dn./ PHEDs/Boards will be in-charge of O & M of the scheme. The PHED will pump water upto the OHT level in each Panchayat/ local body.
2. The PHED will raise the water demand charges to each of the village Panchayat/local body every month and collect the same from them.
3. The PHED will initially incur expenditure on power consumption charges, repair and maintenance charges and will be adjusted against the water tariff collected from the Panchayat/local body..
4. The PHED Field Engineers will prepare Annual Maintenance estimate and obtain necessary sanction.
5. The source of funding for maintenance is by collection of water charges and by utilisng the fund earmarked as per NRDWP guidelines for the purpose of operation and maintenance out of NRDWP allocation for that year after apportioning the amount between PHED/Boards for maintenance of multi village schemes and rural development Dept. for maintenance of single village scheme. The cost of power consumption charge alone will be about 60 -70%. Therefore any shortfall in meeting out the expenditure for maintenance by PHED may have been compensated by Govt. or by raising the water tariff.

6. The Panchayat will distribute the water equitably to local beneficiary through the distribution system.
7. The delivery point may be a street tap or any house service connection.
8. The Panchayat will collect water charges from the households and also user charges for stand posts / public tap.
9. The Panchayat will remit the water charges to PHED/Boards as per demand raised by EE/Maintenance Dn./PHED./Boards
10. The Panchayat will attend the repair/ replacement of pump set, pipe line from out of water charges collected and from the fund allocated as grant by the Govt. for each Panchayat.

The States/ UTs execute single village/ habitation water supply scheme (over one Panchayat only) should hand over to the Panchayat after execution for operation and maintenance of all infrastructure right from source to Distribution system. The Panchayat will pay electricity charges, attend repair works and collect water charges from the house hold connections as per the tariff fixed by the Govt. In the case of CWSS covering more than one Panchayat, the common components such as source, pumping main will be under the maintenance of PHED/ Boards/ and water will be pumped up to OHTs whereas the OHT and Distribution system will be handed over to respective Panchayat/ local body. The PHED/ Boards/PRIs will collect monthly water tariff from the Panchayat/ local body as per the tariff rate fixed by the Govt. (on Kilo liter basis based on water meter reading) The Panchayat/ local bodies will collect water charges from the beneficiary (on flat rate/ per connection basis)

As being followed in some State PHEDs/ Boards/PRIs, the Engineer who is in charge of operation and maintenance of the CWSS along with the maintenance staff may be placed under the control of respective District Collector/District Panchayat for effective monitoring of performance of CWSS including collection of water tariff in Panchayat and urban local body and to discuss and sort out the issues of the complaints received. The District collector/DWSM will review maintenance of combined water supply schemes every week.

Role of State /UT Govt. in maintenance of multi village water supply schemes (MVWSS) and single village water supply schemes (SVWSS)

1. To make policy decision like fixing of water tariff, O&M, undertaking major repairs, augmentations etc.
2. Review of operation and maintenance of MVWSS and SVWSS
3. Review of aspects of sustainability of water supply schemes
4. Coordination with various department of state Govt. like Rural development Dept, Electricity Dept. Health Dept. etc.
5. Allocating special funds to execute contingent plan so that the water supply schemes are not affected by inadequate power supply, adverse seasonal conditions like drought period and natural calamities like earthquake, tsunami, cyclone etc.

Role of District Panchayat/DWSM

1. Chairman of District Panchayat Head of DWSM may review the status of functioning of all water supply schemes every fortnight.
2. District Panchayat council may pass resolution for taking up water supply maintenance works for components which are under the maintenance of Panchayat such as extension of distribution main and replacement of pipe line in the existing distribution system of the CWSS /multi village WSS, reallocating the zilla parishad funds to various block Panchayat for execution of work, utilizing technical supervisory manpower available with the respective block Panchayat

3. The chairman District Panchayat/DWSM/ Head of Division/ Secretary District Panchayat should review the stage of implementation of the works sanctioned by District Panchayat.
4. Works such as construction of additional OHT/ New OHT or for making any changes in the existing components which are under the maintenance of Panchayat shall also be taken with the concurrence of the PHED / Board.

Role of Block Panchayat (if exist)

1. Block Panchayat council will also pass resolution for taking up water supply maintenance works such as replacement of old pipes, extension of distribution main etc. and execute such works uitlising the services of Block Engineer with the funds available with the Block Panchayat.
2. Works such as construction of additional OHT/ New OHT for making any changes in the existing components which are under the maintenance of Panchayat will be taken up with the concurrence of the PHED/ Board.
3. The Head of block Panchayat/ BDO will review the progress of works with the Engineers of the Block.

Role of Gram Panchayat/(GP)

1. The village Panchayat/GP will pass resolution for taking up maintaining works in the distribution system of the multi village WSS which is under their maintenance. The works may be such as attending leaks and burst, changing gate valve, extension of pipe replacement of old pipe line etc.
2. The VP/GP may pass necessary resolution for executing the above works utilizing the Panchayat funds. The GP will maintain their single village water supply schemes and attend repair works in components such as pump sets, pipeline etc. and collect water charges as fixed by the respective state government.
3. The GP may provide house hold connections after passing GP resolution and after obtaining the concurrence of PHED/Boards/PRIs Engineer.
    - The Panchayat may incur expenditure on water supply maintenance work as per the finance limit as fixed by the Govt./DWSM, when expenditure exceeds the limit, the countersignature of the Block Engineer may be obtained.
    - The GP will collect water charges from the house holds at the rate fixed by the Govt./DWSM.
    - The Gram Panchayat shall remit the monthly bulk water charges to the PHED/ Board every month.
4. For effective maintenance of the Distribution system, the VWSC will assist the gram Panchayat.
5. The gram Panchayat shall consult and discuss with the VWSC before taking any decision/resolution regarding water supply maintenance works

    - The VWSC is fully empowered to supervise and monitor all water supply maintenance works.
    - The VWSC may undertake the following activities
    - Shall assist the Panchayat to appoint a suitable candidate for the post of scheme operator/ plumber etc.
    - Shall ensure equitable distribution of water for all section of village population.
    - Shall assist the Panchayat in collection of water charges.

- To check whether the water distributed is free from contamination and whether having the adequate residual chlorination using Field test kit or by sending water sample to the nearest labs of PHED/Other institution.
- To clean and chlorinate the OHTs periodically
- To assist the Panchayat in hundred percent collection of water charges.
- To close all illegal connection and pit taps.

6. Cases pertaining to theft of water and damage to assets of water supply scheme shall be treated as public offence.

18.2 Community Participation and motivation in maintenance of WSS

The task is to build confidence and general awareness among the community for taking up the management of water facilities for their satisfaction water supply protection, sustainability of system; Community mobilization can be taken up through different activities & with different focus groups.

Forming User group with specific representation of community for different activities may be the first step. A sub group with specific responsibility may also necessary in case of monitoring the continuity in practice among users. The details of which may be seen in annexure.

- Monitoring Progress and Performance
- Monitoring, Audit and Reporting

The DWSM should put in place a monitoring and audit system. This should be a combination of annual reports from the Gram Panchayat and field audits. The annual reports would give progress against implementation dates, indicating actions taken where there has been slippage, and provide actual cost returns against budgets. These returns would be reviewed by the DWSM with a view to deciding whether a visit should be organised to carry out a field audit. In addition to field audits to sites where there appear to be problems, it would be desirable to have a few random visits to check on reliability of annual returns. However, the emphasis should be on support to Gram Panchayats other than where falsified returns are suspected.

The DWSM should produce and publish annual reports on their work for rural water supplies. Some important elements in the report would be:

1. Statements on state policy on expected minimum service standards, subsidies and cost recovery from charges,
2. Lists of Gram Panchayat which have established good baseline data, which have prepared drinking water safety plans and operating plans,
3. Lists of Gram Panchayat which have submitted service improvement plans to the district for funding consideration, and those which have been approved,
4. Progress on implementation of each approved improvement programme and where available the impact on service performance.

Reviews of tariff implementation and cost recovery.

The monitoring and audit role is that of a regulator and the style of regulation should reflect the requirement, which is one of capacity building rather than enforcement. Generally the approach would be to identify difficulties and help Gram Panchayat find solutions.

18.3 Complaint communication and redressal system

The states/UTs are executing single village water supply schemes andMulti Village Water Supply Schemes (meant for multi village and multi urban local body). The single village Water Supply Schemes or multi village water supply schemes may be either maintained Boards or by the Panchayts There may be cases in respect complex of multi village water supply schemes that the common components like sources, transmission main and pumping up to

the OHT may be under the maintenance of PHED/Boards and the distribution of water from OHT to the beneficiary is vested with the Panchayat.
Deficiency in maintenance and service delivery may occur in water supply scheme components pertaining to the scheme components maintained by PHED/Boards or panchayat. In such a complex scenario, general public who intend to make a compliant on deficiency in maintenance of the scheme may not be aware who is the concerned authority to set right the deficiency and to whom to make the complaint.

Hence the following mechanism for complaint communication and redressal may be setup as follows.

18.3.1 Complaint communication

1. A complaint cell may be created in the District Collector's/DWSM office equipped with necessary soft & hard skills duly giving adequate publicity about the nature of complaint can be made and also the details such as E. mail address/ fax number/ telephone number/ postal address etc. of the complaint cell.
2. As being done in the case of emergency need of Police/ Fire service , a three digit toll free number may be assigned for lodging urgent complaint through Telephone/ mobile phone.
3. A member of public who instantly come across any leakage/ overflow or any deficiency in maintenance of the schemes may lodge a complaint to three digit number.
4. Immediately after receipt of complaint, a compliant number will be assigned and informed to the complainant, if the complaint is received by phone/ E-mail.

18.3.2 Redressal System

Complaint received may be examined and determined who the maintenance agency/VWSC is within an hour of receipt of compliant. If it pertains to Multi village scheme (up to OHT), it may be informed by phone/ E. mail to the PHED/Board and if it is related to Panchayat it will be intimated to the local body/ Panchayat. If the complaint is received through post also the above system may be adopted.

- The respective maintenance agency should intimate the stage of action taken the next day to District Complaint Cell.
- The District Complaint Cell will create necessary files/ documents in computer and register the name and address of complainant, mode of receipt of compliant, assigning of complaint number, agency who is attending the complaint, present stage of action taken etc.
- The complaint cell may inform the facts such as who is the agency attending the complaints, their contact number and stage of action taken to the complainant, the next day after receipt of complaint (by phone./SMS/ E .mail)
- The respective maintenance agency should report final stage of action taken within two days to the complaint cell (by phone/SMS/ E. mail)
- The complaint cell may inform the final action taken, to the complainant immediately after receipt of details received from the concerned maintenance agency.
- The District collector may review the status of complaints received every week.

ANNEXURE
SPECIFIC IEC AND MOBILIZATION ACTIVITIES

- Display Boards/ Wall Paintings:
- Habitation level meetings:
- Women SHG activities/Youth group/club activities:
- School teacher and Student Programs:
- Competition among user groups on performance:
- Appreciation and Award programs:
- Diary writing / Documentation of all activities:

18.4.1 Community Involvement for Sustainable Water Supply Management

The community may be involved in following aspect:
Assess Water Supply At Distribution Points:

A) street walk

- A group of community members like VP President, VWSC members, Community leaders, WSHG members, local PF users, school students, etc can be mobilized and taken for a street walk to identify the present condition of various infrastructures like PFs/HSCs including condition of platforms, Distribution Pipelines, OHTs.
- The students, SHGs, VWSCs, can note the conditions of all infrastructures in a notebook.
- In case of any damage and availability of pit taps, unauthorized connections and illegal tapping in particular, the duration from which the same prevails shall also be recorded.

B) Tap Stand Study

1. The supply condition at water drawl points such as PF's and HSC's can be assessed along with the community conducting tap stand study at different locations namely near OHT, Tail end, higher elevation, etc.. The simple procedure of recording time for filling a standard pot during the start of supply and during the end of supply hours can be followed.
2. The VWSC and SHG members along with school teachers may be involved in measuring and recording of time and assess the discharge in lpm. Assess the present low-level in discharge and discuss with the community the reasons for such low level of service and the immediate measures the community can undertake to improve the service condition.
3. The low cost measures such as introduction of valves to feed higher elevation, zoning and looping for attaining equal distribution, attending leakages, removal of illegal tapings which can be done through VP or from common community fund can be discussed for service improvement. Any individual who can voluntarily assist can also be explored and motivated.
4. After showing an improvement in the service the community can be Triggered to take decision for removal of pit taps in PF's, HSC's and also removal / regularization of unauthorized connections and unwanted PF's.
5. Notify at public places including schools, the resolution of community on the actions to be taken, the date and time for undertaking such activities by the community and the request the other people to join on that day of action.
6. Source Protection Measures:
    a) The supply of safe water is very essential in the context of acceptability and satisfaction of the community. The first step towards this will be protecting the sources from any contamination.
    b) The Sources can be inspected with the community members like VP President, VWSC members, Community leaders, WSHG animators & members, local PF users, school students, Teachers, VHN, Pump Operator, etc and the

environmental conditions around the sources shall noted and recorded as "Sanitary Survey".

c) The specific condition of different type of sources which may lead to non-portability / contamination (some items are given below for guidance) can be recorded in "Sanitary Survey".
   i. Waste water drain running along or very nearer to the source,
   ii. GL of the source in respect to the road and drain level which may lead to water over flow and stagnation,
   iii. Open well not covered with mosquito net / fish net.
   iv. Damaged and corroded portions in HPs & Open draw wells.
   v. Leaky valves and valve pits in case of EPL / CWSS.
   vi. Any other conditions as deemed fit.

d) The ill effects of sources in the above condition shall be discussed with the community members, necessity to undertake remedial measure to avoid diseases and for safe water supply.

e) The immediate remedial measures can be taken up along with the NSS Volunteers, students, SHGs and youth club by voluntary labour, individual donations and VP support.

f) The NSS Volunteers, students, SHGs and youth club members can undertake certain measures as mentioned below for source protection.
   - Leveling the ground around the power pump sources for avoiding water stagnation
   - Diverting the waste water drain running near the source
   - Repairs to Hand Pump platform and providing proper drainage (with soak pits if necessary)
   - Open well shall be covered with mosquito net / fish net to avoid breeding of mosquito and falling of waste materials.
   - Attending leaky valves at tapping points in case of EPL / CWSS.

Revival of Traditional Sources:

- A special walk along with the VP President, VWSC members, SHGs, Students, teachers etc., can be undertaken to the areas of the traditional water sources such as pond, Ooranies, tanks, lakes, etc.. along with the community.
- The condition of the supply channels and water bodies regarding any encroachments, weeds growth, debris, open defecation, present usage shall assessed and recorded using the Students, NSS volunteers, SHGs, youth groups, etc.
- The community discussion shall be done on the prevailing conditions and to take up remedial measures with specific responsibilities among the members.
- The NSS volunteers, School students, SHGs and youth club members can be motivated to clean up the ponds, Ooranies, tanks, supply channels, etc by fixing up a date for activity. Any refreshments can be arranged through community common fund or individual donors.
- Specific community decisions to safeguard the traditional water bodies can taken in the following points:
- Banning open defecation particularly around water bodies and supply channels and water supply sources.
- Avoiding direct disposal of waste water in to the supply channels as well as water bodies and to undertake interception and diversion works for the waste water channels / drains.
- Banning the disposal of debris and garbage in the supply channel and water bodies.

- The community comprising members from SHGs, VWSC and students can form "Water Bodies Protection Team" to monitor the implementation of community decisions

OPERATION & MAINTENANCEASPECTS

Fixing supply timings:

- *A meeting with the community comprising of all sector representatives particularly women shall be* organized to regularize the water supply timing which will be advantageous for their day to day work.
- Depending upon the availability of water and their daily requirement the community shall fix the timing & duration of water supply through PFs and HSCs.
- This can be monitored by a street user group - 'Supply monitoring Team' by recording the date & time of supply in a notebook. This team may include the SWHG members and school children etc.

Optimizing Pumping Hours

The major portion of the O&M cost goes towards the Electricity Bill, which directly depends on the hours of Pumping. It is necessary to arrive at an optimum pumping hours in order to economize the O&M cost.

Most of our water supply schemes are having Bore well as source and hence to find out an optimum pumping hours a 'Pumping Test' may be conducted as detailed below:

- To conduct this test a community team consists of Pump Operator, VWSC members, WSHG members and school children may be formed.
- During the first day the water may be pumped to the OHT and the time taken to fill each foot in OHT can be recorded till the OHT is filled fully or to the daily pumping level.
- The time taken to fill each foot may vary with respect to yield.
- Note the level where there is an increase in time for filling a particular depth is more than the time taken for previous depth. Then that level as well as pumping hours can be taken as "first optimal stage".
- During the second day the pumping can be stopped after the first optimal stage and few hours may be given for recuperation of the water in the source. The pumping can be done for the second time up to the depth during which the pump discharge remains almost same including the time taken for that depth again. This can be taken as the "second optimal stage" pumping.
- By repeating the above process for one or two days the optimum hours and stages of pumping can be arrived and accordingly the pumping can be don*e in future.*
- However the above optimum pumping hours may differ depending upon the various seasons and hence such a test has to be conducted at frequent intervals (say once in three / four months) and the pumping hours can be fixed accordingly.
- To make this process sustainable a monitoring mechanism may be made with a user group including some school children besides the Pump operators, VWSC members SHG members etc.
- The pumping time, duration and meter reading on each day may be recorded in a notebook and also can be written on the walls of the pump room for public *information*

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Model Wall tabulation:

Name of the habitation:						
Names of User team member		1…………….		2……………..		3…………….
Date:	Pumping Hours			Electricity Meter reading		
	Time of start	Time of finish	Total hours of pumping	Reading at start	Reading at finish	Total units consumed
This week: Total pumping hours				Total Units consumed		
Last week: Total pumping hours				Total Units consumed		
Comparison: Excess / less						

Alignment watch

- Generally the major loss of water is due to leakage in the pumping main and Distribution system.
- To identify and attend immediately such leakages, 'Alignment watch Team' with user group (Students, WSHG members Youth groups) and pump operator shall be formed.
- One or Two members in the team can do alignment walk along pumping main preferably during pumping hours and along Distribution system during supply hours.
- If they found any moisture on the soil above alignment or any visible leakages it shall be recorded in a separate note book and reported to the VP / Pump operator to undertake repairs.
- If any burst has identified the team members shall stop the pumping / close the out let of OHT respectively in case of Pumping main or distribution.
- The team shall ensure repairs and restoration by the VP by intimating the occurrence to the proper person such as President, pump operator / plumber.
- If sufficient funds are not available for certain repairs, the user team can mobilize the community to spare from common funds or any individual to donate. The same shall be displayed in the notice board of the village.

PFs & HSCs maintenance

- The quality of service delivery to the public mainly depends on the condition of PFs & HSCs. Any damage to the PF platforms, stagnation of water, garbage around the PF, taking bath and washing around the PFs will have different level of contamination to the drinking water collected.
- For maintaining the hygiene at PFs & HSCs, which in turn will keep the water safe, necessary measures at user level and VP level has to be taken.
- With the community consensus the VP can resolve to ban the other uses at the PFs apart from collecting water.
- The HSC users shall be motivated for not using the water for non-domestic purpose such as Gardening, cattle washing etc.

- All the HSCs and PFs shall be ensured with proper taps.
- A street wise PF user group to monitor the proper water drawl at PF shall be formed. This group shall mobilize the user not to practice any community banned activities.
- This street wise PF user group will also conduct 'Tap stand Study' once in a month and record the supply level in a note book. If any undue decrease in supply level noticed, the team will report to the pump operator / VP to set right.

Water Conservation

- The satisfaction of the community can be made permanent only when suitable water conservation measures as a part of general O&M is practiced both at household level and community level. Some conservation measures as mentioned below can be inculcated among the people by IEC and consensus.

At Household level:

- The households can collect and store water for daily requirements alone.
- The balance water after usage from the previous day collection in the houses need not be poured as waste and the balance requirement alone shall be collected afresh for the new usage.
- Proper handling and storing of water in the houses shall be practiced to avoid contamination.
- The Water collected for domestic usage should not be used for gardening; the kitchen and bathroom wastewater shall alone be used for gardening.
- Soak pit can be constructed by the households for the disposal of kitchen and bathroom wastewater.

Community level

- At PFs the tap shall be kept closed when the water is not collected and taps shall also maintained without leakage.
- All taps can be replaced to avoid leakage as well as for a uniform appearance
- Bathing and washing shall not be practiced at PFs
- Traditional sources shall be maintained as water sources and free from any garbage, debris, and wastewater.
- Rain water collection and recharge shall be practiced and community involvement should be provided.

Water Quality & Disinfections

- Maintaining the quality of water supplied is a major task and the community involvement in practicing and monitoring is important in all aspects. The general measure to maintain the water safe for consumption is detailed below for community level adoption.
- The OHT shall be cleaned periodically (once in a month). The user group members such as Youth club and other villagers shall be fixed to do cleaning on voluntary basis and to monitor the regularity. The Last date of cleaning and the due date to clean shall be written on the OHT wall / Columns.
- The pipeline shall be cleaned and scoured once in two months. The pump operator and user group shall be trained to undertake the cleaning and monitoring the regularity.
- Regular chlorination using bleaching powder on daily basis inside the OHT depending upon the quantity of water to be supplied. The Pump Operator and Women SHGs shall

be trained to carry out the disinfection. The user team shall also maintain a separate register on the bleaching powder dosage.

- The Open wells and hand pump sources shall be given bleaching powder dosage once in two months using the fitter and WSHGs trained to remove the HP head and refit.
- Testing of residual chlorine at PFs and HSCs by the Users group and students, recording the results in a note book for improving performance.
- The user group and students shall monitor all types of source protection measures for its proper condition.
- The community shall do water quality analysis using field kit once in four / six months and students & SHGs shall be trained to carry out test. The Water sample analysis for all parameters shall be done by the VP once in year at the nearby PHED/Water Boards/Departments District Lab.

Financial Management

The VWSCs and the other user group shall be trained to prepare the monthly or bimonthly O&M Budget based on the actual condition.
The individual households shall be motivated such that they pay the tariff regularly.
The Electricity meter reading card shall be properly entered and maintained by the User group / Pump Operator.
The User group shall monitor the O&M budget regularly and shall take measures to reduce O&M costs.

CHAPTER – 19
SYSTEM MANAGEMENT

19.1 Need for Effective Management

Lack of effective management or poor management is the single largest factor which causes the greatest negative impact on the performance of water supply systems. This is clearly evident when there are no well-defined objectives, no long term planning, no short term programming or budgeting. Hence there is a need for guidance to the manager's in-charge of the O&M of rural drinking water supply systems in formulating and implementing activities aimed at improving the efficiency and effectiveness of O&M. The ultimate objective of the managers shall be to provide to the consumer the best quality service at the lowest cost.

19.2 System Approach to Management

19.2.1 Approach

In a system approach, each water supply organisation is considered as an overall agency within which is a range of organizational systems. Each organizational system is known by its area of specific action and represents specific functions. These systems can be implementation, operational, planning, administrative support (transport, supplies etc.), financial, human resources and management information. These main systems can be further classified according to the differences in decision making and information processes, inputs, outputs, interactions and interconnections. The processing of information linked to the management activities is the basis for determining targets, fixing priorities, schedules, responsibilities, distribution of resources and the entire decision-making process performance maintaining etc.

19.2.2 Advantages of System Approach

This approach enables managers to describe and reorganize the service framework of a water supply agency and to allocate resources so that targets can be achieved. This approach will also be the basis for management control to measure results, take corrective action, formulate new parameters and distribute new resources. This approach allows managers to study functioning of the agency, relationships between various wings of the agency.

19.2.3 Operational System

The objective of an agency's operational system is:

- To establish standards for the delivery of water that is satisfactory in respect of quality, quantity, continuity, coverage and cost.
- To maintain the installations and equipment in a condition that will ensure that they can be operated satisfactorily, function efficiently and continuously, and last as long as possible at lowest cost, and
- To produce information on the water supply and their component units with specific reference to their functioning and their adequacy to meet the needs of users. Thus enabling the agency to evaluate the performance of the installations and the effectiveness of the services.

19.2.4 Component Elements

The component elements of a water supply operational system are collection, treatment, storage and distribution of water including customer support. Main functions in O&M are:

- Installations and equipment will be operated in order to carry out production and distribution of drinking water.

- Monitoring of the functions of operation of the facilities.
- Monitoring the agency's services regarding quality, continuity and coverage of water supply.
- Carrying out maintenance activities efficiently and economically.
- Monitoring the performance of the equipment and evaluating the effectiveness of maintenance.
- Maintenance information gathered for pointing out potential problems suchas weakness of structures, reliability of equipment and identifying obsolete equipment and determining how long the facilities can function usefully.
- Maintenance objectives and standards are set-forth so that maintenance activities yield maximum benefit at minimum cost.

19.3 Management Information System (MIS)

Management Information System is defined as a formal system of making available to the management accurate, timely, sufficient, and relevant information to facilitate the decision making process to enable the organisation to carry out the specific functions effectively and efficiently in tune with organisation's objectives. Organisations have many information systems serving at different levels and functions within the organisation. The data fed into and others can also be fed. Each agency has to decide as to which information is relevant and then evolve its own procedures for accurate collection, measurement, recording, storage and retrieval of data. The MIS can be developed either by manual data collection or by use of software.

The efficient and effective performance of an agency depends on a clear relationship between management activities such as planning, organisation, selection and training of staff coordination, direction and control of the functions of the agency. The interaction between the individuals at different management levels, together with use of information in the decision making process, is important to the agency's performance. Each of the management levels has different centers of decision and each of these is supported by an information system.

19.4 Database of Rural Water Supply Scheme

To achieve efficient and effective performance of rural water supply scheme following, The Data Base of the scheme is required to be collected and analyze in due course of time. This will help in deciding, life of scheme, time schedule for augmentation of each component, sustainability of source, and the system, and to provide safe drinking water in adequate and desired quantity ,at adequate pressure at convenient location and time and as economical as possible on a sustainable basis.

The Formats of data base are appended as categorized as below

Sl. No.	Particulars	Annexures
1	General	1
2	Surface Source	2-A
3	Ground Water Source	2-B
4	Rising Main	3
5	Storage Tanks	4
6	Pumping Machinery /Power Filtration	5
7	Filtration Unit	6
8	Distribution System	7
9	Water Revenue	8
10	Re-Organization / Contingency Works/ Deposit Work	9
11	Water Quality Assurance Monitoring	10

ANNEXURE-1

DATA-BASE OF RURAL WATER SUPPLY SCHEME (GENERAL FEATURES)

S. N.	Name Of Village	Name Of District	Population-2011 Census			Demand Of Water As Per Norms For 2011 In Kld	Source					Service Level In Lpcd		Coverage Area (In Sq. Km.)		S.C/S.T. Basties (In Numbers)		No .Of Connect-ion	No. Of P.S.Ps.	Zero/ Low Pressure Area (In %)	Year Of Commissioning	Design Period	Next Augmentation Required In The Year
			TOTAL	S C	S T		SUREACE	Uinder Ground (In Numbers)				Normal	Summer	Total Area	Coverage Area In %	Total	Covered						
								T.W	HP	S.PH. Bore Well	O. W.												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

ANNEXURE-2-A

DATA-BASE OF RURAL WATER SUPPLY SCHEME (SURFACE SOURCE)

S.N.	Name Of Village	Name Of District	Type Of Source			Capacity In Mcft.	Dependability 0n The Basis Of Last 30 Yrs. Dates	Average Annual Reservation Of Water (In Mcft.)	Gap Between Reservation And Demand	Proposed Solution To Meet out The Gap	Suggestions For Improving Dependability If Required
			Major Dam/ Reservoir/Canal System (Name)	Minor Dam/ Reservoir (Name)	Local Anicut /Ponds Etc. (Name)						
1	2	3	4	5	6	7	8	9	10	11	12

ANNEXURE-2-B

DATA-BASE OF RURAL WATER SUPPLY SCHEME (GROUND WATER SOURCE)

S. N	Name Of Village	Name Of District	Type/Name of Source Tw/ O.W	Yield In Klh	Power Availability In Hrs.	Total Production In Kld.	Chemical Parameters(In Ppm)					Total Depth	Water Level	Draw-Down	Seasonal Variation	Gap Between Demand And Supply	Solution Suggested	Details Of Casing Pipes (Blind/Strainer)	Geological Formation	
							Fluoride	Salinity	Arsenic	No 3	Iron								Over Burden (In Mts.	Average Strata Range
1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17	18	19	20	21	22

ANNEXURE-3

DATA-BASE OF RURAL WATER SUPPLY SCHEME (RISING MAIN)

S.No	Name Of Village	Name Of District	Reference Of Rising	Type/Pipe Martial	Class Of Pipe	Length Of Pipe Line	Year Of Laying	Design Period	Overall Condition Of R. Main	Maximum Pressure On Line	No. Of Valves Provided		
											Sluice Valve	Air Valves	N R.V.
1	2	3	4	5	6	7	8		9	10	11	12	13

ANNEXURE.4

DATA-BASE OF RURAL WATER SUPPLY SCHEME (STORAGE TANKS.)

S.N	Name of Village	Name Of District	Equalising Basin / Diggies /Raw Storage Tank					Clear Water Reservoir					Service Reservoir/ Ground Level Reservoir				
			Location	Type Of Storage Tank	Capacity In Klh.	Yrs. of Construction	Present Working Condition	Location	Type (Rcc / Masonary /Steel	Capacity In Klh.	Yrs. Of Construction	Present Working Condition	Location	Type (Rcc / Masonary	Capacity In Klh.	Yrs. Of Construction	Present Working Condition
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

ANNEXURE- 5

DATA-BASE OF RURAL WATER SUPPLY SCHEME(PUMPING MACHINERY/POWER.)

S.N.	Name of Village	Name of district	Pump Houses							On Source (TW/ O W Etc.)							Amp.	Power Factor	Name/Type Of Power Feeder(Common/Separate)	Availability of Power	Average Monthly Power Charges
			Location	Type Of Pumps	Duty Condition Of Pumps			Efficiency	Year Of Installation	Location	Type Of Pumps	Duty Condition Of Pumps			Efficiency	Year Of Installation					
					KW	Discharge In Lph	Head In Mts.					Kw	Discharge (In Lph)	Head In Mts.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

ANNEXURE- 06

DATA-BASE OF RURAL WATER SUPPLY SCHEME (FILTRATION.)

S. No	Name Of Village	Name Of District	Slow Sand Filter					Rapid Sand Filter					
			Location	Capacity	Year Of Construction	Design Period	Operational/ Non Operational (Efficiency)	Location	Capacity	Over Loading Capacity	Year Of Construction	Design Period	Operational/ Non Operational (Efficiency)
1	2	3	4	5	6	7	8	9	10	11	12	13	14

ANNEXURE NO- 07

DATA-BASE OF RURAL WATER SUPPLY SCHEME (DISTRIBUTION SYSTEM.)

S. N	Name Of Village	Name 0f District	Total Area Of Town/ City In Sq. M.	% Area Coverage	Total S.C Beasties	Coverage Of S.C Beasties	Total S.T Beasties	Coverage Of S.T .Beasties	Total Minority Beasties	Coverage Of Minority. Beasties	Distribution Network			Old/Damaged Line Required Replacement			% OF Zero / Low Pressure Area
											Type AC /DI /MS /GI/PVC Etc.	Size In MM	Length In Mts.	TYPE AC/DI/MS/ GI/PVC Etc.	SIZE IN MM	LENGTH IN Mts.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

ANNEXURE-8

DATA-BASE OF RURAL WATER SUPPLY SCHEME (WATER REVENUE.)

S. N.	Name of Village	Name of District	Number Of Water Connection															Outstanding Rs. In Lacs		
			Domestic			Commercial			Industrial			2009-10		2010-11		2011-12		More than 10YRS.	More than 5yrs.	More than 1yrs.
			Flat Rate	Metered		Flat Rate	Metered		Flat Rate	Metered		Target	Achievement	Target	Achievement	Target	Achievement			
				Working	Out of Order		Working	Out Of Order		Working	Out of order									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

ANNEXURE- 9

DATA-BASE OF RURAL WATER SUPPLY SCHEME(RE-ORGANISATION/CONTINGENCY/DEPOSIT WORKS)

S.No	Name Of Village	Name Of District	Re-Organisation Schemes /Contingency Scheme(Last 3years)												Deposit Works						
			Sanctions Detail			Activities									MLA/ MP Led			BADP		Other If Any	
			Year	Cost In Lacks	Completion Year	Source Tw/ Hp /S Ph. In Numbers	Max. Transportation Of Water/Day	Rising Mains		Storage Tanks	Distribution		Filter Plant	Other Works	Name of ML.A / M.P	Name of Work	Sanction Cost Rs. In Lacs.	Name of work	Sanction Cost Rs. In Lacs.	Name of work	Sanction Cost Rs. In Lacs.
								TYPE /SIZE	LENGTH		TYPE/ SIZE	LENGTH									
1	2	3	4	5	6	7		8	9	10	11	12	13	14	22	23	24	25	26	31	32

ANNEXURE-10

DATA-BASE OF RURAL WATER SUPPLY SCHEME (WATER QUALITY ASSURANCE MONITORIN

S. No	Name Of Village	Name Of District	No. Of Field Testing Kits Procured	No. of Field Testing Kits Distributed	No. of Water Sources Tested	No. of Source Found Contaminated Above Permissible Limit	No. of Sample Tested	Chemical Parameters found (In Ppm)				
								Chloride	Fluoride	Nitrate	Arsenic	Iron
1	2	3	4	5	6	7	8	9	10	11	12	13

LIST OF PARTICIPANTS

Workshop for Preparation of Operation & Maintenance Manual for Rural Water Supply Schemes

1. ESCI , Hyderabad, 24 – 26 April, 2012

S. No.	Name(Shri)	Designation	Organisation
1.	Paras Nath Singh	Executive Engineer DW & S Division, Tenughat	Drinking Water & Sanitation Dept., Ranchi, Jharkhand
2.	Arshad Ali	Executive Engineer DW & S – Mech. Division (Urban), Ranchi	-do-
3.	Sanjay Kumar Jha	Executive Engineer DW & S Division, Dhanbad -	-do-
4.	Amlendra Kumar	Tech. Advisor, DWS Circle, Ranchi Urban	-do-
5.	Manpal Singh	Chief Engineer	PHED, Haryana
6.	Bibekananda Mohapatra	Chief Engineer, RWS&S, Odisha	Rural Water Supply & Sanitation,Jal O Primal Bhawan, Unit – V, Bhubaneswar
7.	Sumant Ku. Harichandan	Superintending Engineer, Cuttack	-do-
8.	T. D. Sandilya	Chief Engineer Raipur	PHED, Raipur CG
9.	A K Sahu	Superintending Engineer PHE, Durg	-do-
10.	C.R. Gajbhiye,	Superintendent Engineer, Nashik Research & Training Centre (NRTC),	Water Supply & Sanitation Department, Mantralaya, Mumbai-400032
11.	Anand Ghodke,	Technical Advisor, (WSSO)	-do-
12.	Dr. S.D. Umrikar,	Senior Geologist, (WSSO)	-do-
13.	C.S. Sankule	Chief Engineer (Indore Zone)	PHED, Bhopal
14.	Sunil Kumar Khare	Executive Engineer (CCDU)	- do -
15.	Ph. Yalma Singh	Superintendent Engineer, Plg. & Monitoring circle	PHED, Manipur
16.	N. Bipin Singh	Executive Engineer Imphal East PHE Division	- do -
17.	A.K. Shrivastava	Chief Engineer (Urban)-cum- Member Secretary, Executive Committee,	Bihar State Water and Sanitation Mission, Patna
18.	B.P. Ojha	Director (WQ)	- do -
19.	D.K. Saxena	Chief Engineer	State Water Sanitation Mission, Dept. of RD, Lucknow
20.	Harish Chandra	Superintendent Engineer (Rural)	U.P Jal Nigam, Lucknow
21.	B. V. Prasad	Executive Engineer (O & M)	RD & PR Dept, Karnatakao
22.	Krishna Murthy M.N.	Dy. Director	- do -
23.	Satyanarayan S.L.	Executive Engineer	-do-
24.	Subran T.C	Chief Engineer	Kerala Water Authority Thiruvananthapuram
25.	D.K. Das	Chief Engineer	PHED, Guwahati, Assam
26.	Deepak G. Ramanandan	Executive Engineer	GWS&SB, Gandhi Nagar, Gujarat
27.	R. Chakrapani	Project Director & Chief Engineer, CCDU	RWS&S Dept. Govt. of AP, Hyderabad
28.	J. Viswanatham	Chief Engineer	-do-
29.	Vidya Sagar	Jt. Director	- do -

30.	B. Rajeswara Rao	DEE	-do-
31.	Prasad B.S.R.	AEE	-do-
32.	Anand Paul	Executive Director	-do-
33.	G. Rukkaiah	Sr. Geologist	-do-
34.	N.V.V. Satyanarayana	Executive Engineer, Nalgonda	-do-
35.	N. Parvatha Reddy	Executive Engineer, Madanapalli	-do-
36.	M. Ram Mohan Rao	Chief Engineer	-do-
37.	R. Kondal Rao	Chief Engineer	-do-
38.	H. Umakantha Rao	Chief Engineer	-do-
39.	Sudhindra Mohan Sharma	Consultant	MDWS, New Delhi
40.	Dr. Dinesh Chand	Addl. Adviser	- do -
41.	Sudheer Saxena	Sr. Consultant & Team Leader	- do -
42.	C.L.N. Sastry	Adviser, WR	WRD, ESCI
43.	G.D. Ojha	Head, WR	- do -
44.	B. Leela Prasada Rao	Sr. Faculty, WR	- do -

2. MoDWS, CGO Complex, New Delhi, 13-14 th March, 2013

S. No.	State	Name (Shri)	Designation
1.	Andhra Pradesh	Alla ba ksh	Executive Engineer
2.	Assam	Uday Khound	Executive Engineer
3.	Chhattisgarh	M.A.Khan	Director WSSO
4.	Gujarat	D.G.Ramchandani	General Manager/E.E.
5.	Haryana	Lalit Arora	Executive Engineer
6.	Himachal Pradesh	Joginder Chauhan	Executive Engineer
7.	Jharkhand	Sri Ram Bilash Prasad Sinha	Superintending Engineer
8.	Kerala	Sree Kumar M.	Executive Engineer
9.	Maharashtra	C.R. Gajbhiye	Superintending Engineer
10.	Mizoram	C. Lallunghncma	Superintending Engineer
11.	Madhya Pradesh	B. K. Srivastava & P. K. Raghuvanshi	Superintending Engineer& Executive Engineer
12.	Meghalaya	K.D. Talukdar & Y.K.B.Singh	Superintending Engineer& Executive Engineer
13.	Punjab	N.K. Dhir & J.S. Dhand	Superintending Engineer & Executive Engineer
14.	Tripura	Shankar Banik & B.R.Saha	Superintending Engineer & Executive Engineer
15.	Tamil Nadu	R. GANESH	Executive Engineer
16.	Uttar Pradesh	Shrinivas Mishra	Water Supply Engineer, State Water & Sanitation Mission, LKO, UP
17.	West Bengal	Ritam Battacharya	Dy. Superintending Engineer
18.	MDWS	S.C.Sharma	Dy. Adviser,(Retainer)
19.	MDWS	V.K.Bhatla	Assistant Adviser(Retainer)
20.	MDWS	Saleem Haider	Assistant Adviser(Retainer)
21.	MDWS	Dr. T. K. Das	NRC, Consultant(IFC)
22.	MDWS	Dr. P. K. Jha	NRC Consultant

ABBREVIATION

AMC	Annual Maintenance Contract
ASHA	Accredited Social Health Activist
BIS	Bureau of Indian Standards
CWR	Clear Water Reservoir
CAG	Comptroller and Auditor General of India
CBO	community-based organization
CCDU	Communication and Capacity Development Unit
CGWB	Central Ground Water Board
CWC	Central Water Commission
DDP	Desert Development Programme
DPAP	Drought Prone Areas Programme
DPR	Detail Project Report
DWSM	District Water and Sanitation Mission
FCRI	Fluid Control Research Institute
GIS	Geographical Information System
GoI	Government of India
GP	Gram Panchayat
GPS	Global Positioning System
GSI	Geological Survey of India
GLR	Ground level Reservoir
HADP	Hill Areas Development Programme
HRD	human resource development
ICT	Information and Communication Technologies
IEC	Information, education and communication
IMIS	Integrated Management Information System
IT	Information Technology
IIH&PH	Indian Institute of Hygiene and Public Health
IIRS	Indian Institute for Remote Sensing
IIT	Indian Institutes of Technology
M&I	Monitoring and Investigation
MIS	Management Information System
MoU	Memorandum of Understanding
NGO	Non-governmental organization
NGRI	National Geophysical Research Institute
NIC	National Informatics Centre
NICSI	National Informatics Centre Services Inc.
NICD	National Institutes of Communicable Diseases
NIRD	National Institute of Rural Development
NRDWQM&S	National Rural Drinking Water Quality Monitoring & Surveillance
NRHM	National Rural Health Mission
NRSC	National Remote Sensing Centers
NRDWP	National Rural Drinking Water Programme
O&M	operation and maintenance
OBC	Other Backward Classes
PHC	Primary Health Centre
PHED	Public Health Engineering Department

PRI	Panchayati Raj Institution
R&D	Research and Development
RDBMS	Relational Data Base Management System
RGNDWM	Rajiv Gandhi National Drinking Water Mission
SC	Scheduled Caste
SHG	Self-help group
SLSSC	State Level Schemes Sanctioning Committee
ST	Scheduled Tribe
STA	State Technical Agency
SWSM	State Water and Sanitation Mission
SCADA	Supervisory Control and Data Acquisition
SR	Service Reservoir
TA	Travelling allowance
TSC	Total Sanitation Campaign
UFW	Unaccounted for Water
UT	Union Territory
VAP	Village Action Plan
VWSC	Village Water and Sanitation Committee
WSSO	Water and Sanitation Support Organization
WHO	World Health Organization
WQM&S	Water Quality Monitoring & Surveillance
WSSB	Water Supply & Sanitation Boards
VCCSC	Vigilance Committee, Consumer Service Committee

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