सत्यमेव जयते

Government of India

DRAFT

Operation and Maintenance Manual For Rural Water Supplies 2013

Ministry of Drinking Water and Sanitation

CONTENTS

ABBREVIATION

AMC	Annual Maintenance Contract
ASHA	Accredited Social Health Activist
BIS	Bureau of Indian Standards
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
GIS	Geographical Information System
GoI	Government of India
GP	Gram Panchayat
GPS	Global Positioning System
GSI	Geological Survey of India
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
TA	travelling allowance
TSC	Total Sanitation Campaign
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
CWR	Clear Water Reservoir
FCRI	Fluid Control Research Institute

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 and clean drinking water in adequate and desired quantity ,at adequate pressure at convenient location and time and as economical as possible 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, which is a routine function."

"Maintenance is defined as the art of keeping the structures, plants, machinery and equipment and other facilities in an optimum working order. Maintenance includes preventive maintenance or corrective maintenance, mechanical adjustments, repairs, corrective action and planned 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 federal Constitution of India and, therefore, the States are vested with the constitutional right on the planning Implementation 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 in Rural Sector, the economic and social program of the country is formulated through five-year plans

The Public Health Engineering Department (PHED) is the principal agency at the State level for planning and implementation of water supply and sanitation program. In a number of States, statutory Water Supply & Sanitation Boards (WSSBs) have taken over the functions of the PHEDs. The basic objectives for creation of WSSBs have been to bring in the concept of commercialization in the water supply and sanitation sector management and more accountability

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 (G.Ps./VWSC.) wherever needed. The expenditure on rural water supply and sanitation is met out by Ministry of Drinking Water and Sanitation under NRDWP guide lines, and also 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 deterioration of the useful life of the systems necessitating premature replacement of many system components. As such even after creating such assets by investing millions of rupees, they are unable to provide the services effectively to the community for which they have been constructed, as they remain defunct or underutilized most of the time.

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

i) Lack of finance, inadequate data on Operation & Maintenance
ii) Inappropriate system design; and inadequate Workmanship
iii) Multiplicity of agencies, overlapping responsibilities.
iv) Inadequate training of personal.
v) Lesser attraction of maintenance jobs in carrier planning.
vi) Lake of performance evolution and regular monitoring.
vii) Inadequate emphasis on preventive maintenance
viii) Lake of operation manual.
ix) Lake of appreciation of the importance of facilities by the community.
x) Lake 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.

1.4 NECESSITY FOR AN O&M MANUAL

The Manual on Operation and Maintenance is a long felt need of the 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 74^{th} Amendment to the Constitution, all the Rural water supply schemes is to be operate and maintained by local bodies (G.Ps./P.S./Z.P.),therefore to make them easy to understand the operation and maintenance system of rural water supply schemes ,the necessity for preparation of operation and maintenance manual was realized.

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

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 programmes 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.

1.5.2 Standard operating procedures

are essential to identify what local operators should do in terms of routine operation and maintenance related to water sources, storage and treatment units, and distribution systems including connections; and for annual budgets of operating expenses and income, and annual surplus/deficit. Someone with good experience and analytical 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 what to do and when, the operator can quickly gain hands on experience and build confidence to do the job well. Likewise, the operator's fees and incentives can be made transparent and this also helps to improve their performance.

1.5.3 Service improvement plans

are important to define management improvements, service delivery improvements and actions to improve accounts, billing and revenue collection. The benefits and costs need to be considered and priorities set (such as immediate, this year or next year).

CHAPTER 2

STRATEGY

2.1 INTRODUCTION

The large investments made to construct utilities intended to provide facilities for water supply are becoming unproductive in the sense that the objective for which they have been installed is not achieved mainly on account of poor Maintenance. Often the investments become unproductive, and a larger amount of money is required to replace and rebuild the system components. Interruptions in service occur owing to the breakdown of equipment as a result of poor maintenance. The utility control organizations are not able to ensure that the maintenance staff follows valid practices to achieve proper maintenance. The management of Water supply systems in the water authorities is receiving relatively lower priority. Lack of funds coupled with lack of enthusiasm among the operation and maintenance staff to keep schemes in working condition; lack of training, lack of motivation among the staff may be reasons for the present status of the water supply systems

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The activities which require for good operation and maintenance areas follow.

2.2 Preparation of a plan for operation and maintenance.

A program or a plan has to be prepared for operation and maintenance of every major unit to be specifically written for that particular unit. The overall operation and maintenance plan of an organization is made up of collecting operation and maintenance programmes of various individual units. This plan has to contain procedures for routine tasks, checks and inspection sat intervals viz. daily, weekly, quarterly, semi-annually or annually.

The individual plans must be prepared for all units and all pieces of equipment. Each unit must have a plan to fix responsibility, timing of action, ways and means of achieving the completion of action and contain what objectives are meant to be achieved by this action. Generally actions recommended by the manufacturer or by the engineer 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 designer construction will be a good starting point for writing a sound programme. This plan has to be followed by the operation and maintenance staff and also will be the basis for supervision and inspection and also can be used for evaluation of the status of operation and maintenance.

2.3 Providing required personnel to operate and maintain.(Management Re-orientation)

The management shall become service oriented and be prepared to run the organization on a commercial basis. The management must be able to motivate the staff to perform better. It is essential that the organization responsible for O&M is well qualified, experienced, efficient and still economical.

2.4. Providing Capacity building programs for the O&M personnel

The training program can be organized through Key Resource Center authorized by the Government of India under NRDP in different States .The personal who are already available or chosen to carry out the action contained in the program may have to be trained through special courses or by "on the job training "to ensure that these personal are thoroughly trained to carry out the action listed in the plan of maintenance. The supervisors can be trained initially and they can later train their operators.

2.5 .Availability of spares and tools for ensuring maintenance

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 and material, 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.

2.6. Preparation of a water audit and leakage control plan

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) is near about 20 to 55 % .The huge quantum of water is being wasted which also leads to reduction in water revenue therefore it become essential to plan the conservative use of water i.e. water auditing and leakage control. Water auditing could lead to prioritizing action required to reduce the physical and revenue losses.

2.7. Preparation of a water audit and leakage control plan.

Power charges are likely to 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.

2.8. Establishing a 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. Control of O & M expenditure can be achieved by preparing annual budget of income and expenditure of O&M, based on realistic estimates.

The organization shall realize that full cost recovery of O&M cost by user charges is must ,the tariff structure is to be evolved to recover the O&M cost and have a surplus for debit servicing and depreciation .

2.9. Information Education Communication

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 can prepare Information- Education-Communication material and use the services of voluntary organization/NGOs in disseminating the information among the consumer and create awareness among the public.

2.10. 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 matter like water conservation ,proper use of water by people and the need to pay price of water at affordable level .Water uses' committee can be formed by active involvement of NGOs to periodically review the local problems, advice the agencies on improvements needed and future of planning ,upkeep of utilities within their jurisdiction ,encourage the people to remit water charges regularly and encourage hygienic habits.

2.11. Evaluation

The success of operation and maintenance program is shown by a decline of frequency of prearranged shutdowns, and emergency repairs. Improved O&M may result increased availability of water to be supplied, hence yielding more revenue, further the cost of repairs may also decline and equipment life may also increase by the proper implementation of the maintenance programme .

2.12.Records and Repairs

A record and report 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 the problems of each equipment requiring the attention to repair and replacement crew or other specialized service personal.

CHAPTER -3

RURAL WATER SUPPLY SCHEME

3.1 INTERODUCTION

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 in 1972-73with the launch of Accelerated Rural Water Supply Program (ARWSP). With the passage of time, the program was modified in 1986-87 as Technological mission and re named as Rajeev Gandhi National Drinking Water Mission in 1999-2000.

The Rural Water Supply (RWS) Program has now 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. The program is named as National Rural Drinking Water Program 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.

3.2. Types of Rural Water Supply Schemes.

The classification of rural water supply scheme is based on following criteria

A) **Coverage of villages** i) Single village Scheme

ii) Multi village scheme

B) **Source of scheme i) Surface Source Scheme –**

a) Canal based scheme, b) Reservoir based scheme,

c) Natural stream based schemes

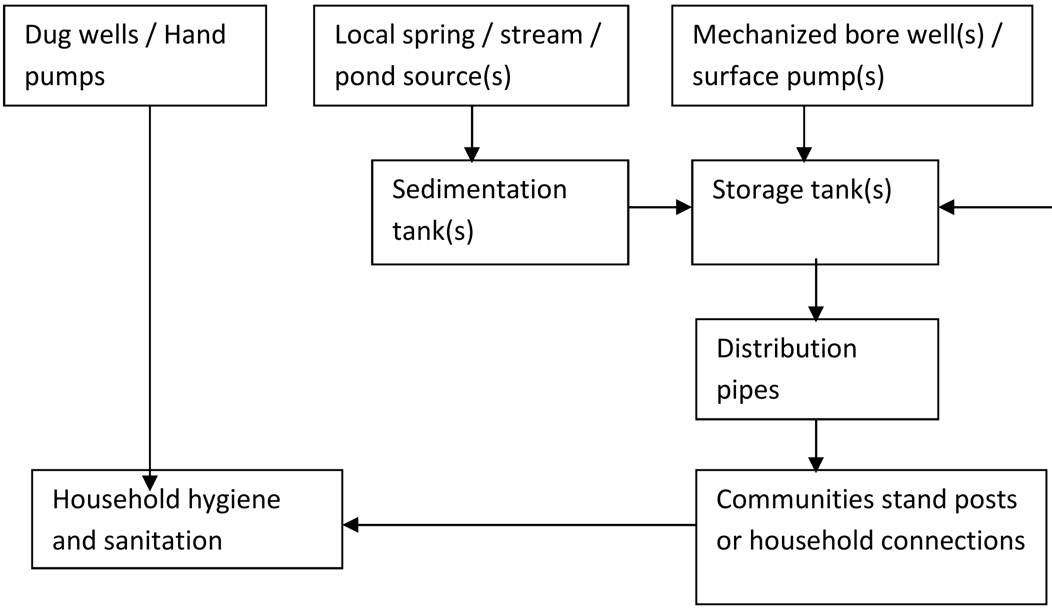
Ii) Ground Water Source Scheme

a) Manually operated scheme-Baories, Traditional Open wells, Hand Pumps scheme
b) Power pumps scheme-Tube Wells, Single Phase bore wells, Open wells.

C) Based on Gradient of ground-a) Gravity flow scheme, b)Pumping main scheme

As per norms the villages having population below 500 is provided with H.P. scheme, The villages having population below 4000 is provided with Pump & Tank/ Panghat (P&T) Scheme. The villages having population 4000 and above is provided with Piped Water Supply Scheme.

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



3.3 Local springs, streams or ponds with gravity fed piped systems

People in hilly, rural areas often depend entirely on spring sources, gravity flow, and piped water supply with tap connections Gravity fed piped systems include the following components: a storage tank with inlet (from the source), outlet (to stand posts or household connections) and washout, and overflow pipe; distribution pipeline with valves and valve boxes often of PVC or PE for buried sections and galvanized iron for exposed sections and house connections; stand posts made up from galvanized iron delivery pipe possibly encased in a concrete pillar, with a tap, and with a concrete platform to direct dirty water to a drain; and a drain and soak away at least three meters from the stand post.

Field observations indicate the following types of problems are common: spring and stream sources are not protected and are contaminated by animal fecal matter and garbage; sedimentation and storage tanks are not covered or properly cleaned; in rural growth centers tapping by private pipelines is common; treatment is non-existent and, in particular, chlorination is not practiced; pipes are leaking, badly repaired, and are often surrounded by animal fecal matter and garbage; household storage and handling is unsafe and hand washing with soap is not practiced.

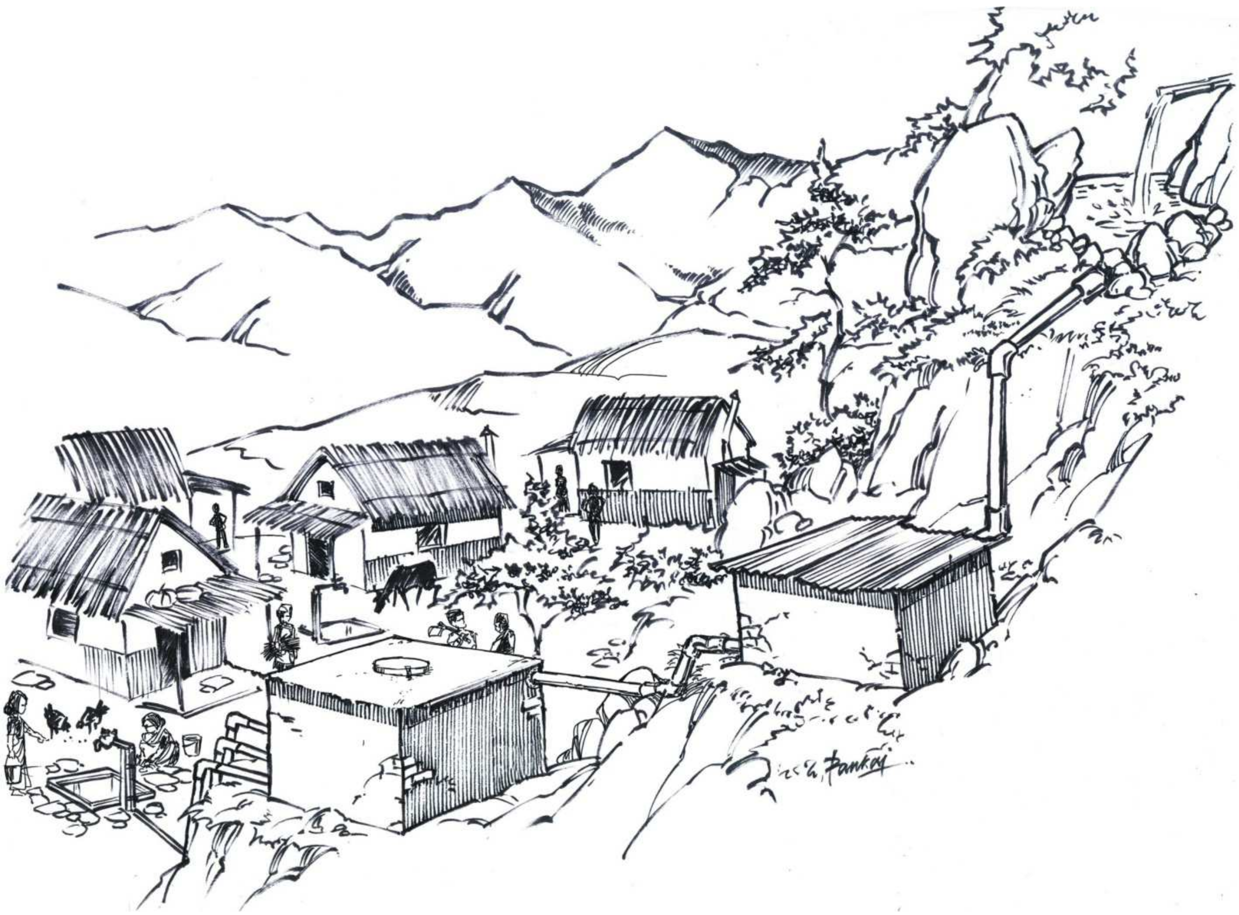


Figure 3: Typical Gravity Fed Piped System

3.4 Components of Rural Water Supply Scheme

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

1 Source
2 Transmission System
3 Filtration
4 Pumping Machinery
5 Disinfection
6 Storage
7 Distribution system
8 Instrumentation
9 Water Revenue
10 Monitoring Information System

CHAPTER -4

SOURCES OF WATER SUPPLY

4.1 NATURAL 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.

4.2 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 The amount of available surface water depends largely upon rainfall. When rainfall is limited, the supply of surface water 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. Canals or open channels can be constructed to convey surface water to the project sites. The water is also conveyed through pipes by gravity or pumping.

4.2.1 USE OF SURFACE RESERVOIR

Method of managing lakes and reservoir used for domestic supplies vary widely depending on local condition. In addition to serving domestic water needs, a reservoir may be used for flood control process, for hydroelectric power generation, and for Agriculture purposes.

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 treating water depends upon row water quality and range from disinfection only to complete treatment.

4.2.2 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 interference with the proper functioning of the intake in which there is either or both a wide fluctuation in water level or the desire to draw water at a depth that will give water of the best quality to avoid clogging or for other reasons

4.2.2.1 PROBLEMS& NECESSORY 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

v) Proper service and lubrication of intake facilities is important

vi) 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

4.2.2.2 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.

4.3 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 .the water in the zone of saturation is called as ground water.

The ground water structure which are mainly used for water supply schemes are as below;

1. Dug well with or without staining wells

2. bore well a) Hand Pump b) Tube well

4.3.1 Dug wells

Dug wells vary in size, shape, depth, lining and the method of raising water. Typically water is raised by a simple bucket and rope passing over a pulley. The well may have a diameter of about 1.5 meters. It may be lined for example with concrete. A headwall and cover should be built to prevent spilt water, rainfall runoff, debris, people and animals from entering or falling inside. A concrete apron is critical to prevent polluted water seeping back down the sides of the well, provide a platform for users to sand on, and direct water away from the well to drainage channels. The well can be fenced.

4.3.1.1 O&M activities for a dug well

The daily O&M activities should include:

- 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
- Report problems to the VWSC

Monthly activities should include:

- Replace the bucket and other parts as needed
- Collect community contributions or user charges and deposit with the VWSC
- Check the concrete apron and well seal for cracks and repair with cement mortar as needed
- Record the water level with a rope scale and report to the VWSC
- Lubricate the components as needed with grease.

Annual activities should include:

- 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 well with a rope scale and report the VWSC

4.3.1.2 O&M resources for a dug well

Unskilled labour (VWSC) 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 by the VWSC.

Finances would be from the VWSC/GP for labour, replacement parts and maintenance equipment.

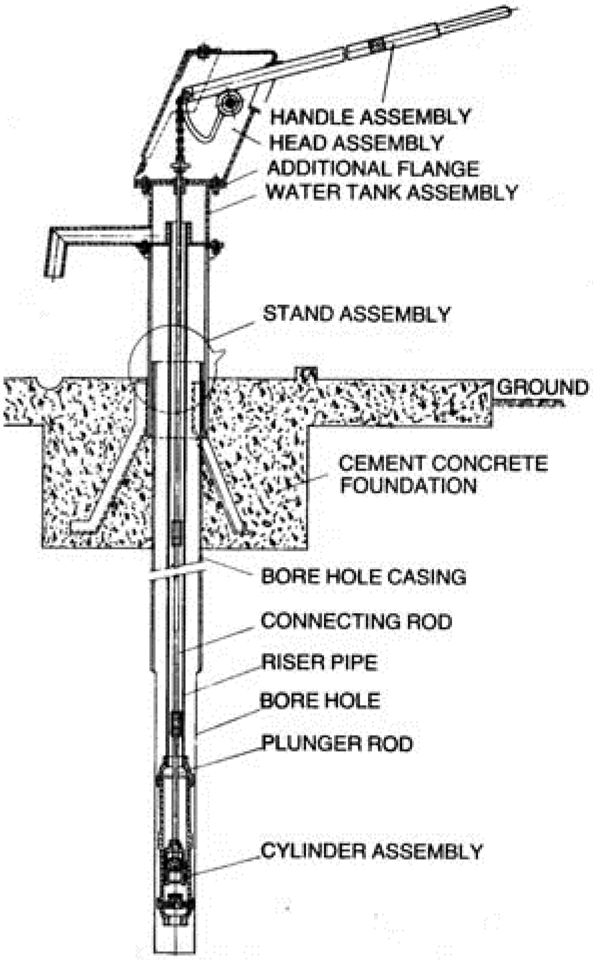
4.3.2 Hand pumps

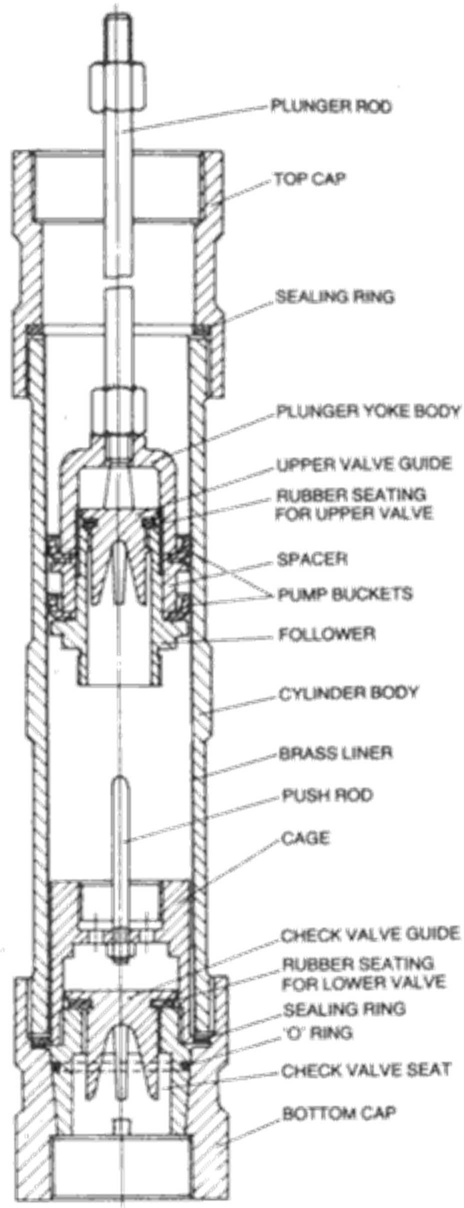
Boreholes may be fitted with a variety of pumps. The India Mark II (Figure 1) and the India Mark III (Village Level Operation and Maintenance) (Figure 2) are the most common hand pumps implemented by the Public Health Engineers.

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. The skills and tools needed to service a Mark II make it unsuitable for village maintenance, and require help from qualified mechanics. While the Mark II has been around for ages and is used in almost every corner of the world, the VLOM advantage in the Mark III 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. In many villages where the resources are scarce, this can often mean the difference between the pump working and or being broken down for a long time. At the same time, the cost of riser pipes is nearly double in Mark 3.

With all hand pumps the borehole is sealed to prevent the ingress of surface water polluting the borehole. A platform is critical so that water drains away to a soak pit/leach pit at least three meters from the borehole. The hand pump should be mounted on top of the borehole so that dirty water cannot pass back into the borehole. The platform must be designed so that it is convenient to use by women and children. The hand pump is bolted to the concrete platform.

Figure 1: India Mark II **Figure 2: Cylinder Assembly of India Mark III Hand Pump**





The notes below are drawn from the Trainers Guide for Grass Root Level Worker Training Package on Operation and Maintenance of Hand pumps (RGNDWM, 1995).

4.3.2O&M activities for a hand pump

4.3.2.1General

1. In the flood prone area, at least one hand pump platform should be constructed / raised 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 to be kept at Village level / GP level / Block level to meet the emergency situation.
5. With the measurement of static water table ,as the water table goes down 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 leads to easy operation of hand pumps
6. The maintenance of hand pump is identified in two categories.

Minor repairs; The repairing of hand pump which does not requires un-lowering of hand pump assembly is treated as minor repair .The minor repairs of hand pump may be made by local village water and sanitation committee (VWSC), this type of repairing involves replacement of handle nut &bolts, repairing of chain, bearing, water body etc., the cost of minor repairing is very negligible, may be Rs.500 per annum per 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 may not be made by local VWSC and will be carried out by hand pump miseries of Panchayat committee.

The cost Analysis for major repairing is assessed below

Labour component :

Hand Pump Mistri	1 Nos	Rs.400/day	Rs 400.00
Casual labour	4 Nos.	Rs.200/ day	Rs.800.00
Jeep with 8 Hrs. Run and 80 KM		Rs.1000/day	Rs.1000.00

			Rs.2200.00

Cost of each hand pump repairing 2200/2.5=880/each (Without material), Labour rates are taken as per market rates.

Material component; On and average repairing of hand pump may requires thrice a year. Normally the material required to be replaced are-

Sl.no.	Particular	No's/per year.	cots in Rs.(Appx.)
1	cup washer.	2	70
2	axle bolt	4	60
3	O-Ring	1	30
4	check valve guide	1in2year	50
5	Follower	1in2year	50
6	rubber seating (for upper valve)	1	30
7	Upper valve guide	1 in 2 years	60
8	Plunger yolk body	1 in 3 year	50
9	Plunger rod	3 meter	120
10	G .I. Riser pipe	3 meter	180
11	Job work(cutting, threading etc.)		200
12	miscellaneous expenditure		500

1400 per annum

Cost of each repairing will be 1400/3=466.66 say Rs.470for each repairing

Total cost for each repairing including the cost of material will be 880+470=Rs.1350

4.3.2.2 The daily O&M activities:

- Check the fittings such as nuts, bolts and handle assembly and tighten them Weekly activities should include:
- 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

4.3.2.3 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

4.3.2.4 Annual activities should include the following checks, and repairs made:

- 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 reassembled.
- 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.
  O&M of hand pumps are to be carried out by user groups and collection of user charges for carrying out the maintenance is left to the user group itself.

4.3.2.5 Disassembly, inspection and reassembly of the hand pump

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
- Life 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

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

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

4.3.2.6 O&M resources for a hand pump

A semi-skilled caretaker is required for daily, weekly and monthly O&M tasks, and to collect user charges. Skilled labour (qualified hand pump mechanic, mason) is needed to work with the caretaker on yearly preventive maintenance, disassembly/reassembly of the hand pump, and to repair the concrete apron and drains.

In a three tier Panchayat Raj system, a Fitter may be appointed to each Panchayat Union / Block (the middle tier) who will work under the Union / Block Engineer. This fitter has to work with the care taker for the maintenance of the hand pump. If it is not possible to appoint a Fitter, the maintenance works if any required, may be entrusted to a contractor.

Materials and equipment include sand and cement, fencing, brushes for cleaning, spare parts for pump repairs, tools for maintenance and repairs, and pipes for the rising main.

Finances would typically be from the VWSC/GP consisting of user charges, GP resources or Government funds for labour, materials and spare parts.

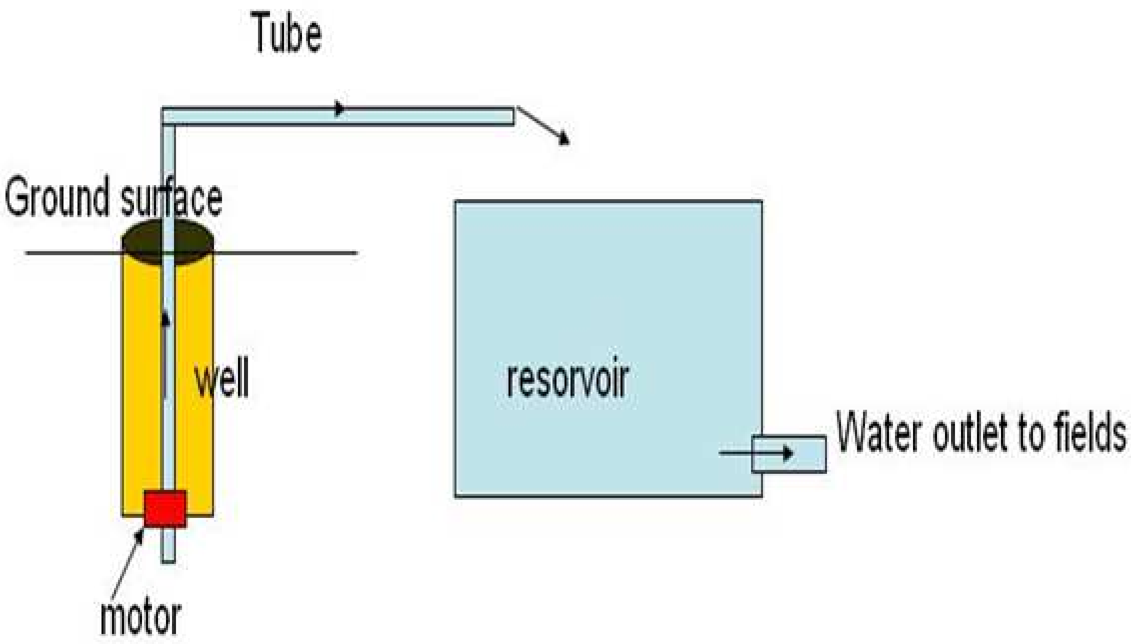
4.3.3 MECHANIZED BORE WELL

4.3.3.1Tube wells, Bore wells with Single Phase 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 lower end is fitted with a strainer, and a pump at the top lifts water for water supply/ irrigation. The required depth of the well depends on the depth of the water table.

The bore well of size 100-125 mm diameter with a depth of approximately up to 50- 90meter ,having a minimum yield of 500 litres per hour, fitted with hand pump equipment is known as hand pump bore well .

The bore well of size 100-150 mm diameter with a depth not less than approximately up to 70- 90 meter, having a minimum yield of 2000-9000 litres per hour, fitted with Single phase submersible pump set /jet pump is known as Single phase bore well. The bore well of size more than 150 mm diameter with a depth not less than 90 meter, having a minimum yield of 2000-9000 litres per hour, fitted with Single phase submersible pump set /jet pump is known as Single phase bore well .



4.3.3.2A TYPICAL SKETCH OF TUBE WELL IS SHOWN AS ABOVE

Boreholes should be fully cased and screened and the top of the borehole sealed to prevent ingress of surface water polluting the borehole. The rising main exits at the top of the borehole through a purpose made cap to prevent contamination of the borehole by surface water and debris. An isolation valve and non-return valve are fitted on a horizontal section of the delivery pipe, adjacent to the bore well. Typically, the pump house is located next to the borehole, and houses the control panel for operation of the electric pump. . Motor service intervals are usually specified in terms of running hours. Therefore, service intervals expressed in days, weeks and months will have to be based on the average number of hours run per day for each installation

4.3.3.3PREVENTIVE MAINTENANCE

According to available data the specific capacity of wells should be measured at regular Intervals either monthly or bi-monthly and it should be compared with the original specific capacity. As soon as 10 to 15% decrease in specific capacity is observed steps should be taken to determine the cause and accordingly corrective measures should be taken. Rehabilitation procedures should be initiated before the specific capacity 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 capacity 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 in need of attention.

Preventive maintenance programme begins with, well construction records showing geological condition, water quality and pumping performance. 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.

4.3.3.4 CONSERVATION OF GROUND WATER

Following are the steps for conservation of ground water

i) Improvement of home plumbing systems
ii) Reuse of recycled water
iii) By creating public awareness by Information, Education and Communication (IEC activities.
iv) By introducing sustainable water tariff
v) By rain water harvesting

4.3.3.5 COUSES OF FAILURE OF WELLS

Well failure may be due to inadequate design, faulty construction and operation, lack of timely maintenance and repair and failures due to mechanical and chemical agents and adverse aquifer conditions. 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.

4.3.3.6 Monitoring of silting of 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.

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 sitting of casing pipe
(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.

4.3.3.7 REHABILITATION OF TUBEWELLS & BORE WELLS

A decision whether to rehabilitate an old well or construct a news hold be based on the cost benefit analysis. Following remedial measures can be taken for
Correcting situation mentioned at (iv) to (viii).

4.3.3.7.1Faulty 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

4.3.3.7.2 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.

4.3.3.7.3Mechanical 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 steps 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', as used in tube well technology, describes a well drilling tool, pump component or other foreign body accidentally fallen or struck in bored wells & wells. The type of fishing tools required for a specific job will depend on the object to be lifted and the positioning which it is lying in the well. It may often be necessary to design a fishing tool to suit particular job. 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 the methods of fishing process.

i. External catch fishing tools
ii. Internal catch fishing tools

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.

4.3.3.8 DEVELOPMENT OF TUBE WELLS

4.3.3.8.1GENERAL

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

1. Redevelopment 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. Redevelopment 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. Redevelopment increases the effective radius of the well and, consequently, its yield.

4.3.3.8.2 Methods of Redevelopment

Following are the methods of well redevelopment:
i) Over-pumping with pump.
ii) Surging with surge block and bailing.
iii) Surging and pumping with air compressor.
iv) Back-Washing.
v) High-velocity jetting.
vi) Dynamiting and acid treatment.
For rehabilitation purpose any suitable method of redevelopment can be used as mentioned above. The largely used method is surging and pumping with compressed air. In this method

4.3.3.9 ARTIFICIAL RE-CHARGING OF UNDER GROUND SOURCE

Artificial recharge of ground water can be achieved by the following:

i)Stream flow harvesting comprising of
- Anicuts
- Gully plugging
- 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

4.3.3.10 O&M ACTIVITIES

4.3.3.10.1 The daily O&M activities of the pump operator should include:

- Operate pump starter
- Open isolation valve
- Check reading on ammeter is normal – stop pump if electric motor is drawing too much current and report problems
- 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.

4.3.3.10.2Weekly activities at the tank should include:

- Clean the pump house
- Testing water quality using a Field Test Kit

4.3.3.10.3 Monthly activities should include:

- Billing and collection, and deposit with the VWSC

4.3.3.10.4 Annual activities should 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
- Record servicing and maintenance in log book4.3.3.11O&M resources for mechanized bore well

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.Financeswould typically be from the household paying water charges, GP or VWSC resources and Government funds.

CHAPTER - 5

TRANSMISSION SYSTEM

5.1 GENERAL-OBJECTIVE OF TRANSMISSION SYSTEM

The overall objective of a transmission system is to deliver raw water from the source to the treatment plants and transmit treated water from treatment plants to the storage reservoirs for onward 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.

The Transmission of water is classified in two categories ,namely A) Open gravity channel (Canal) B) Closed Pipes I) Gravity flow ,ii) Pressure flow

5.2 TRANSMISSION THROUGH CANALS OR OPEN CHANNELS

Open channels and Canals are exposed watercourses for transmission of water from one Specific point to another. Whereas 'Open Channel' is a general name for such a watercourse, a 'Canal' normally forms a part of canal network taken off from a river, a dam or a reservoir.

The canals are meant primarily for irrigation purposes. The canal water is, however, liberally made available for drinking water supply schemes. While designing new canal projects the requirement for drinking purposes is pre-determined and necessary provision made in the design of the canal projects.

The Canal water is transmitted from Canal head works/ Intake well of Reservoir to water works head works is preferably through closed conduits i.e. .through pipes so as to avoid evaporation and seepage losses and have an optimum utilisation of water, even though under specific circumstances open channel/canal is being used exclusively for transmission of water required for water supply schemes.

5.3 TRANSMISSION THROUGH PIPES

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 are:-

1. Cast Iron (CI)
2. Mild Steel (MS)
3. Reinforced Cement Concrete (RCC)
4. Pre Stressed Concrete (PSC)
5. Asbestos Cement (AC)
6. Poly Ethylene (PE)
    i. Low density (LDPE)
    ii. High density (HDPE)

7 Rigid PVC (UPVC)
8 Ductile Iron (DI)
9 Fiber Glass Reinforced Plastic (FGRP)
10 Glass Reinforced Plastic (GRP)
11 Fiber Glass Reinforced Plastic (FRP)

The Specification of pipes should be as per the respective State Policy and BIS specification

5.3.2 Selection of Pipes

The selection of material of pipes to be used depends upon strata of the ground, required sizes of pipes, and uses of pipes .For all types of rising mains preferable D.I./G.R.P/PSC. Pipes may be used depending upon the strata of soil, for Distribution system preferable HDPE. /G.I. pipes may be used depending upon the strata of soil, for service lines & connection HDPE/GI pipes may be used, for Installation of Pumping Machinery Pipes required for Suction and Delivery M.S. pipes may be used, for assembly pipes in Tube wells/Hand pumps G. I .pipes may be used, for casing pipes in bore wells UPVC/AC/MS may be used.
There should be a Pipe Policy of individual State as per their local condition.

5.3.3PRECAUTION TO BE TAKEN FOR LAYING OF PIPELINES

The laying of pipelines plays an important role in Operation and maintenance of pipe line network. During the execution work care should be taken for:

- Preparation of bed for laying of pipelines.
- Providing sand cushion on the base before laying of pipeline, especially in rocky strata.
- Providing cover of at least one meter over the pipes, so as to have resistance to vibration caused by vehicular movement.
- Proper care must be taken for filling the trench after placing the pipes, the trench shall be filled in three layers with proper compaction of soil, first layer should be of fine sand/earth, then with the two layers of normal earth, boulders and stones should not be used in backfill of trench, each layers should be compacted with watering before placing second layer .
- The joints of the pipes shall be tightened uniformly, with proper placing of packing material (rubber gaskets/rings) so as to avoid frequent leakages.
- Air valves, on return valves, butterfly valves, Score valves shall be provided at proper required places, in view with the L-Section.
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5.3.4PROBLEMS IN TRANSMISSION MAINS

5.3.4.1 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.

5.3.4.2Air Entrainment

Air in a rising main, in free form, will collect at the top of pipeline and then run up to higher points. Here it will either escape through air valves or will form an air pocket. With more accumulation of air the size of air pocket will rise. The formation of air pocket will result in an increase of head loss. Other problems associated with air entrainment are: surging, corrosion, reduced pump efficiency and malfunctioning of valves or vibrations. In rare cases bursting of pipes also is likely to occur due to air entrainment.

5.3.4.3 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.

5.3.4.4 Lack of Records

Maps showing the actual alignment of transmission mains are not readily available. The location of pipes and the valves on the ground becomes difficult in the absence of system maps. Some minimum information about the location of pipes and valves and size of pipes and valves and the direction of opening of valves etc. is required, to operate and maintain the system efficiently.

5.3.5 OPERATION SCHEDULE

Mapping and inventory of pipes and fittings in the water supply system
Availability of updated transmission system maps with location of valves, flow meters and pressure gauges 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 tapings if any on the transmission mains. The maps shall be exchanged with other public utilities and also contain information about the location of other utility services like electricity, communications etc. with reference to the alignment of transmission. Hydraulic gradient lines are also to be marked to indicate the pressures in the transmission system. They can be used for identifying high pressure or problem areas with low pressures.

5.3.6 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.

5.3.6.1Activities in 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 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

iv) Costs required carrying out each task.

5.3.6.2 MAINTENANCE OF PIPELINES

Pipeline bursts/main breaks can occur at any time and the utility 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. 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

CHAPTER – 6

CLARIFLOCULLATION AND FILTRATION

6.1 INTRODUCTION

Water to be supplied for public use must be potable i.e., satisfactory for drinking purposes from the standpoint of its chemical, physical and biological characteristics. Drinking water should, preferably, be obtained from a source free from pollution. The raw water normally available from surface water sources is, however, not directly suitable for drinking purposes.
The objective of water treatment is to produce safe and potable drinking water.
Some of the common treatment processes used in the past includes Plain sedimentation,
Slow Sand filtration, Rapid Sand filtration with Coagulation-flocculation units as essential pre-treatment units. Pressure filters and diatomaceous filters have been used though very rarely. Roughing filters are used, under certain circumstances, as pre-treatment units for the conventional filters.

6.2 TYPES OF FILTRATION PLANTS

The types of Filtration Plants are as follows

A) Slow Sand Filter- Plant
B) B) Rapid Sand Filter –Plant
C) Other types of Filter-Plants ,which are not in common use 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. Introduction of the roughing filters will ensure entrapping of such undesirable material prior to the storage structures of the treatment units.

6.2.1SLOW SAND FILTER-PLANT

6.2.1.1 INTRODUCTION

Slow sand filter is most widely used in rural water supply schemes and is an effective, low cost system of water treatment if operated and managed correctly. It is normally one component in a treatment process which may involve preliminary settlement of solids and / or roughing filters and post chlorination. A treatment plant operator, or caretaker, may have a number of responsibilities in addition to the operation and maintenance of slow sand filters. Caretaker responsibilities may extend from the initial source of water to eventual distribution.

Typically there will be two rectangular slow sand filters operating in parallel. During maintenance one filter is kept operating. The filter also comprises pipe work, under-drains, and graded gravel to support the filter sand. The filter is 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.

6.2.1.2 FILTER CLEANING

(**Refer CPHEEO O&M Manual p75-77**)While the filter is in operation, a stage comes when the bed resistance increases so much that the regulating valve has to be fully opened and it is the right time to plan the cleaning of the filter bed since any further resistance is bound to reduce the filtration rate. Resistance accelerates rapidly as the time for cleaning approaches. Indicators may 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 imminence of the end of the run. Without any measurement of the head loss the only true indicator of build-up of resistance is the degree of opening of the regulating valve, though the experienced operator may be able to recognize preliminary visual warnings in the condition of the filter bed surface. A slight deterioration in the effluent quality may be a reason for the need for cleaning. To clean a filter bed, the raw water inlet valve is first closed, 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 level with 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 well 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 some100 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 than will 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 microorganisms 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 weir must be adjusted to suit the new bed level. 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 labourers themselves. Such measures as the provision of boots that can be disinfected in a tray of bleaching solution should be taken. Hygienic personal behaviour must be rigidly imposed, and no labourers 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.

6.2.1.3 Re-sanding

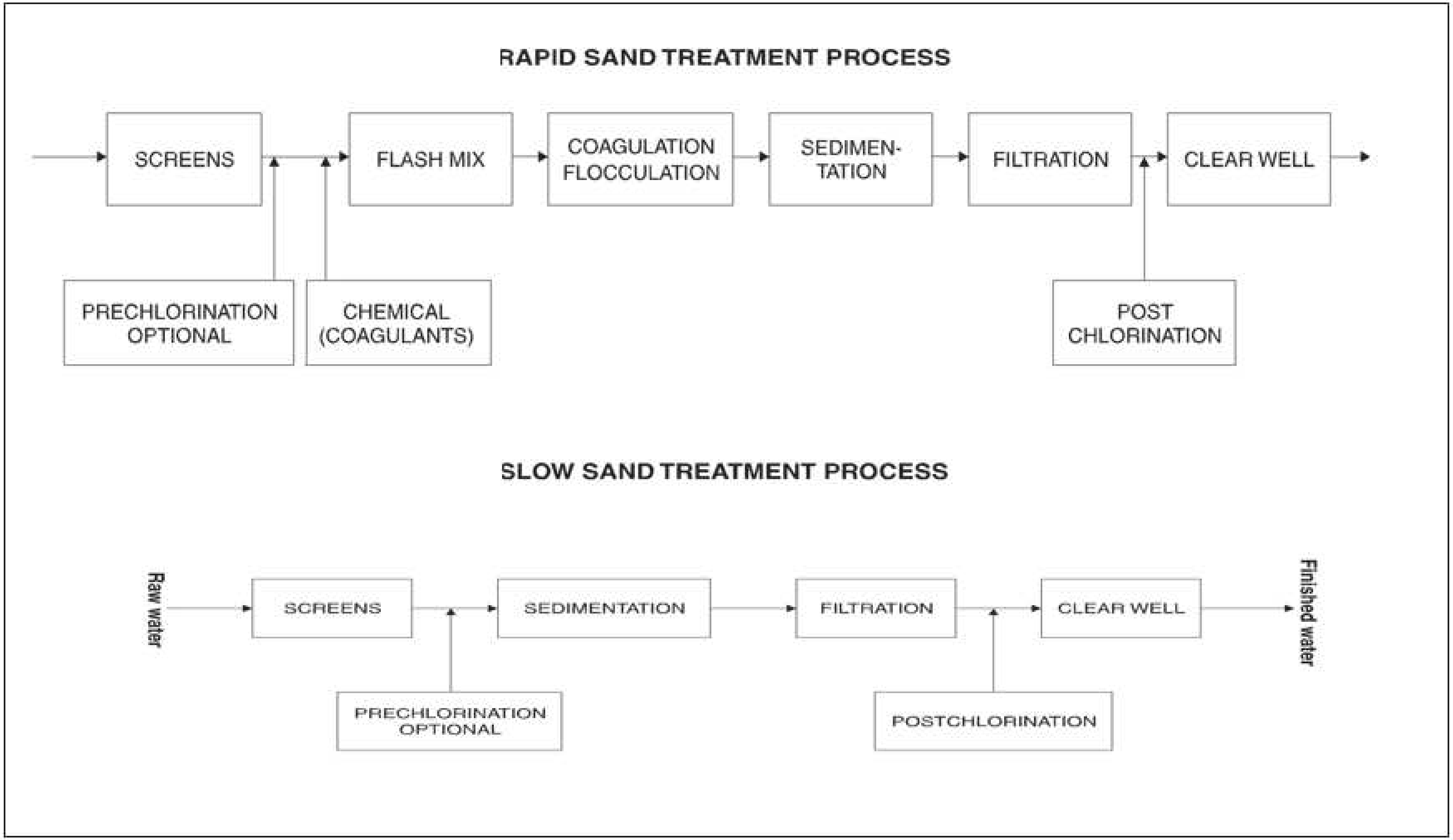
*(**Refer CPHEEO O&M Manual p77-78**)*

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.

During the long period of the filter use/run some of the raw water impurities and some products of biochemical degradation will have been 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 depth of sand should be removed before re-sanding takes place, but it is neither necessary nor desirable that it should be discarded. Instead it is moved to one side, the new sand is added, and the old sand replaced on the top of the new, thus retaining 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.



CONVENTIONAL FILTRATION PROCESS

6.2.1.4 AUGMENTATION OF THE CAPACITY OF AN EXISTING PLANT

Some of the existing slow sand filtration plants need augmentation. The tendency to abandon the old plants and substitute the same with Rapid sand Filtration plants. It is Suggested that wherever possible the old slow sand Filtration plants may be retained on account of the following reasons:

i. Slow sand filter is less likely to go wrong under inexperienced operation.
ii. It does not require skilled attention.
iii. Head consumed is less.
iv. It provides greater reliability of the removal of bacteria.
v. Operating cost is less.

It is, however adapted to waters low in colour, turbidity and bacterial count. Under such circumstances, provision of roughing filters as a pre-treatment unit gives a good result

O&M resources for slow sand filter

Unskilled labour required for re-sanding. Semi-skilled labour (caretakers) is required for plant operation. Skilled labour (supervising manger) is required for supervision.

Materials and equipment include sand, basic tools, valve replacement and spares, flow indicator, turbidity apparatus, bacteriological testing equipment. Finances would typically be from the household paying water charges, GP/VWSC resources and Government funds. The most widely used IRP in the rural area for removing excess iron from drinking water source is based on oxidation, sedimentation and filtration.

6.2.1.5 O&M activities for slow sand filter

6.2.1.5.1 The daily O&M activities should include:

- 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.

6.2.1.5.2 Weekly activities at the tank should include:

- Clean the water treatment plant site

6.2.1.5.3 Monthly activities should include:

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

6.2.1.5.4 Annual activities should include:

- 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

6.2.1.5.5 Every two years, activities should include:

- 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

Irregular checks will include:

- Checks on the functioning of the plant by supervising manager including turbidity tests with a turbidity meter, and bacteriological tests on the filtered water

6.2.1.5..6 Record keeping

Records have to be kept for the following activities.

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

of head.

a) The filtration rate, the hourly variations, if any.
b) 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.
a) The same quality factors of the filtered water.
b) Any incidents occurring e.g. plankton development, rising Schmutzdecke, and unusual weather conditions.

6.2.2 RAPID SAND FILTRATION PLANT

6.2.2.0 Introduction

(Refer CPHEEO O&M Manual p79-105**)** The pre-treatment units which form essential parts of a Rapid sand filtration unit include

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

Filter Operation:

A filter is usually operated until just before clogging or breakthrough occurs or a specified time period has passed (generally 24 hours).

Backwashing:

After a filter clogs or breakthrough occurs or a specified time has passed, 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 required. Surface wash systems provide additional scrubbing action to remove attached flock and other suspended solids from the filter media.

Operational Procedures

(a) The indicators of Normal Operating Conditions

The filter influent and effluent turbidity’s should be closely watched with a turbidity meter. Filter Influent turbidity levels (settled turbidity) can be checked on a periodic basis at the filter or from the laboratory sample tap. However, the filter effluent turbidity is best monitored and recorded on a continuous bas is 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 process equipment (change chemical feed rates). Backwash filters.

Evaluate filter media condition (media loss, mud balls, cracking). Visually inspect facilities.

Figure showing the typical treatment processes

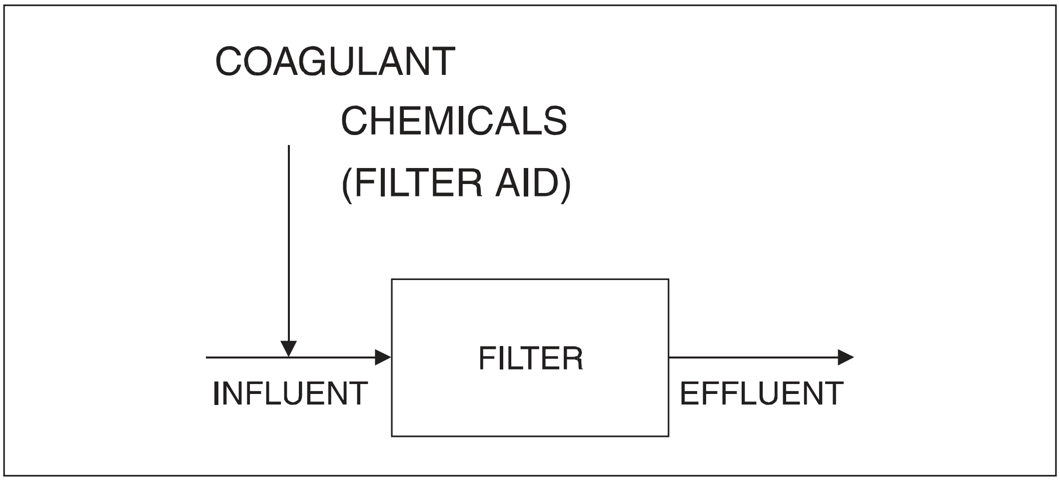


FIG. 5.4 IN LINE FILTRATION

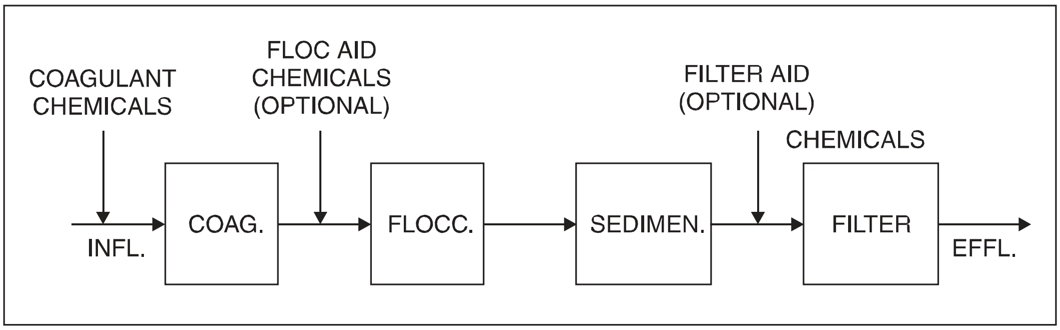


FIG. 5.5 CONVENTIONAL FILTRATION

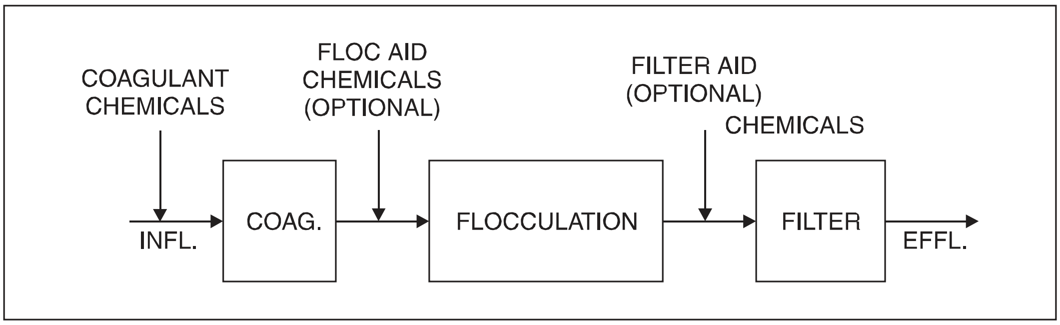


FIG. 5.6 DIRECT FILTRATION

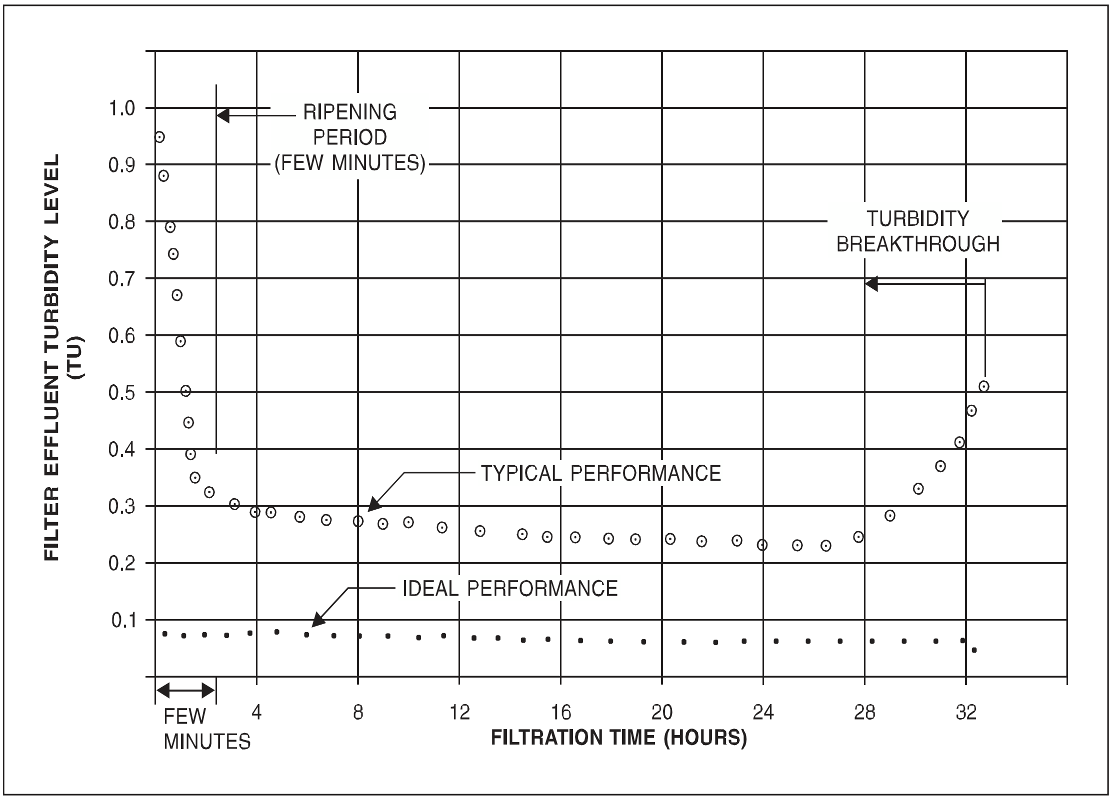


FIG. 5.8: TYPICAL FILTER EFFLUENT TURBIDITY DATA

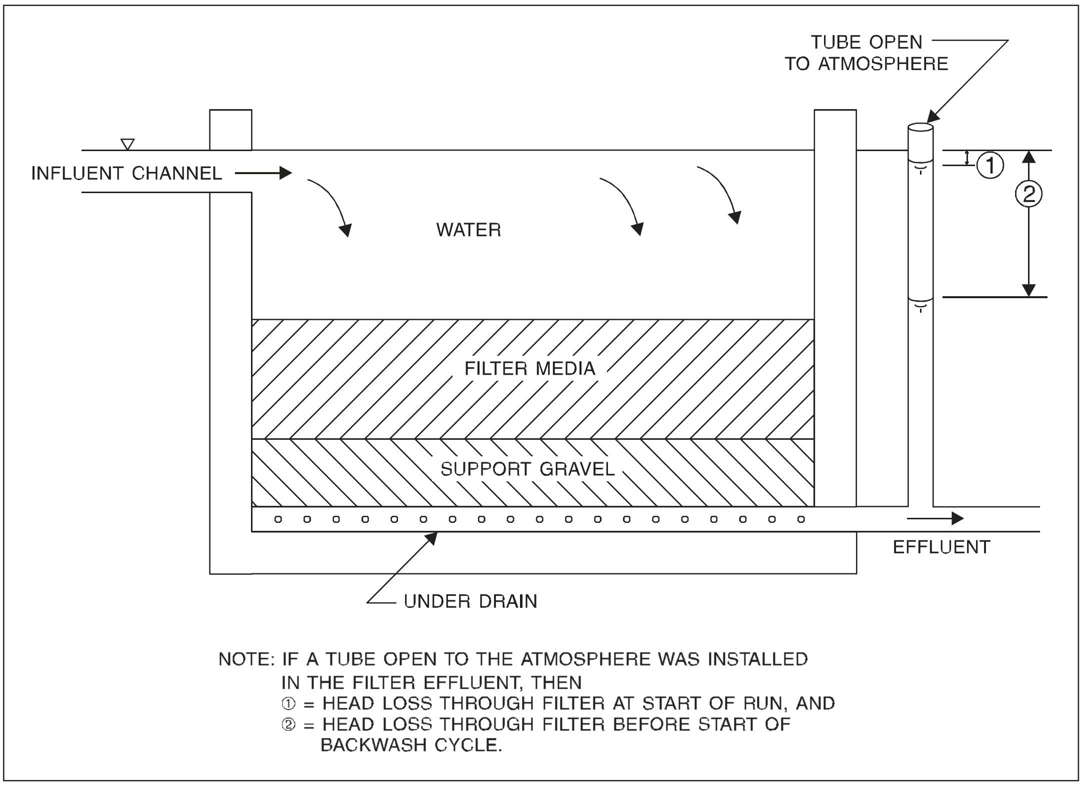


FIG. 5.7: MEASUREMENT OF HEAD LOSS

(c) Important process activities and Precautions.

1. Monitoring process performance is an on-going activity. You should look for and attempt to anticipate any treatment process changes or other problems that might affect filtered water quality, such as a chemical feed system failure.
2. Measurement of head loss built up in the filter media will give you 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 dueto clean media and other hydraulic losses are about 0.9 m. This would permit an additional head loss of about 2.1m due to solid accumulation in the filter.
3. 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 permit you to make appropriate process changes such as adjustment of chemical filter aid feed rate or adjustment of filtration rate.
4. Monitoring of filter turbidity on a continuous basis with a non-line turbidity meter is highly recommended. This will provide you with 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. Present the filter cut-off control at a point where you experience and tests show that breakthrough will soon occur.
5. In the normal operation of the filter process, it is best to calculate when the filter cycle will be completed on the basis of the following guidelines:

   Head loss .Effluent turbidity level. Elapsed runtime.

   A predetermined value is established for each guideline as a cut off point for filter operation .When any of these levels is reached, the filter is removed from service and backwashed.
6. At least once a year one must examine the filter media and evaluate its overall condition. Measure the filter media thickness for an indication of media loss during the backwashing process. Measure mud ball accumulation in the filter media to evaluate the effectiveness of the overall backwashing operation.
7. Routinely observe the backwash process to qualitatively assess process performance. Watch for media boils (uneven flow distribution) during backwashing, media carry over in to the wash water trough, and clarity of the waste wash-water near the end of the backwash cycle.
8. Upon completion of the backwash cycle, observe the condition of the media surface and check for filter sidewall or media surface cracks. You should routinely inspect physical facilities and equipment as part of good housekeeping and maintenance practice. Correct or report the abnormal equipment conditions to the appropriate maintenance personnel.
9. Never bump up a filter to avoid backwashing. 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.

10. 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 two Tables, next page.

6.2.2.1.1COAGULATION AND FLOCCULATION

Purpose

The purpose of coagulation and flocculation is to remove particulate impurities, especially non-settle able solids (particularly colloids) and colour from the water being treated. Non-settle able particles in water are removed by the use of coagulating chemicals.

6.2.2.1.2Chemical Coagulants Commonly used in Treatment Process

The most commonly used coagulant is ferric alum .However, Poly Aluminium Chloride (PAC) is also used as a coagulant. The advantages of PAC are i) it gets properly dispersed, ii) it does not have any insoluble residue, iii) it does not affect the settling tanks, iv) its more effective than alum v) it requires less space(maybeabout50%).The disadvantage of PAC is that it Is less effective in removal of colour.

Coagulation is a physical and chemical reaction occurring between the alkalinity of the water and the coagulant added to the water, which results in the formation of insoluble flocks.

The most important consideration is the selection of the proper type and amount of coagulant chemical to be added to the water to be treated .Overdosing as well as under doing of coagulants may lead to reduced solids removal efficiency. This condition may be corrected by carefully performing Jar tests and verifying process performs anteater making any change in the process of the coagulation process.

6.2.2.1.3JAR TEST

The jar test is I the most widely used method employed to evaluate the coagulation process and to aid the plant operate or in optimizing the coagulation, flocculation and clarification processes.

From the turbidity values of the settled water, settling velocity distribution curves can be drawn. These curves have been found to correlate well with the pant operating data and yield use full information in evaluating pre -treatment, such as optimizing of velocity gradient and agitation and flocculation, pH, coagulation dosage and coagulant solution strength. Such curves cannot be generalized and are relevant to the plant for which the data have been collected through the Jar tests.

In addition, the turbidity, colour and alkalinity of the raw and treated water should be measured or evaluation of the treatment.

TABLE : JAR TEST DATA SHEET

Date& Time	flocculation period with RPM	Settling period	Jar no.	pH	Turbidity	Colour	Alkalinity	Time for first floc. formation	Remarks
			control						
			1						
			2						
			3						
			4						
			5						
			6						

6.2.2.1.4Mixing

The main requirement of the mix is that all the coagulant be rapidly mixed with all the water instantly so as to achieve complete homogenization of a coagulant chemical in the stream to be treated. The reason is that the chemical reaction is extremely rapid, practically Instantaneous, especially in waters with high alkalinity. Since this is not physically possible although desirable, it is important to approximate as nearly as possible to instant and complete Dispersion. To accomplish the mixing of the chemicals with the water to be treated, several methods can be used.

Hydraulic mixing
Mechanical mixing
Diffusers and grid system
Pump blenders.

Mixing of the chemical coagulant can be satisfactorily accomplished in a special coagulant tank with mixing devices. Mixing may also occur in the influent channel or a pipeline to the flocculation basin if the flow velocity is high enough to produce the necessary turbulence. The shape of the basin is part of the flash mix design.

6.2.2.1.5Flocculation Basin - Operation

The objective of a flocculation basin is to produce a settled water of low turbidity which in turn will allow reasonably long filter runs. Following points should be considered during the Operation of the flocculation basins.

6.2.2.1.6Short Circuiting

An important factor that determines the functioning of a flocculator is the short circuiting.
In such a basin, against a predetermined 30 minutes agitation, a large portion may get only 10 minutes while another sizeable amount may get 60 minutes. 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 flock removal problem is compounded then with flocculation which is incomplete and currents introduced into the settling process which further inhibit removal. Properly operated entrance, curtain baffles and exit weirs and launders can significantly improve settling.

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 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 flock particles, which have already formed. If the flock is broken up nothing is accomplished and the filter gets overloaded.

6.2.2.1.7Dosing 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 flock particles. The velocity gradient is gradually reduced from the first to the third unit. The concepts of velocity gradient and tapered flocculation have been discussed in the Manual of Water supply and Treatment (1999 edition).

6.2.2.1.8Interaction with sedimentation and Filtration

The processes of coagulation and 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 and flocculation are too light to settle out and will not be large enough to be trapped during filtration process.

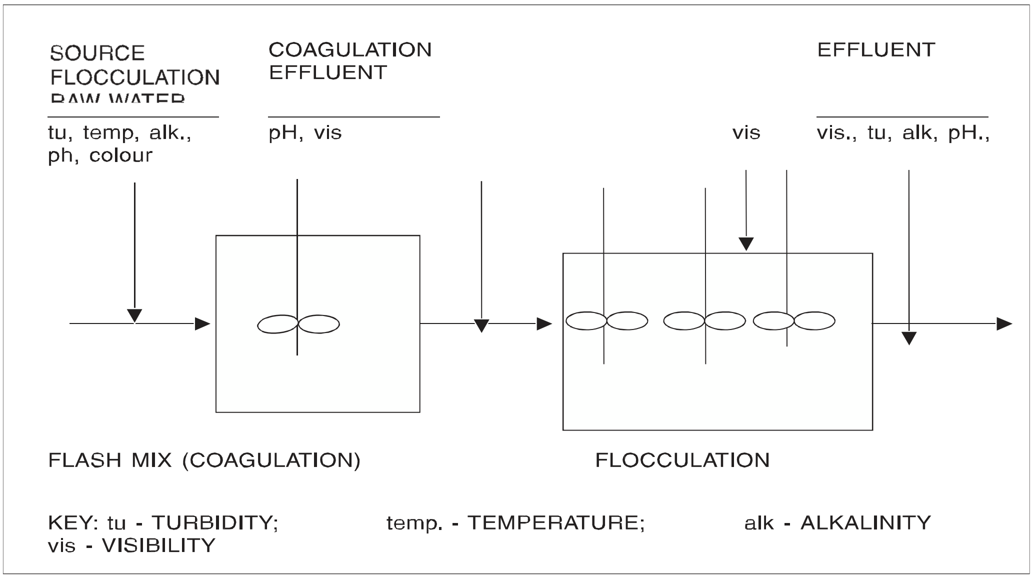
Since the purpose of coagulation – flocculation is to produce particle removal, the effectiveness of the sedimentation and filtration processes, as well as overall performance, depends upon successful coagulation - flocculation.

6.2.2.1.9 Coagulation – Filtration 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.

Fig. (Next page) shows the overall plan view of the coagulation-flocculation process of a typical plant.



6.2.2.1.10 Examination of the Flock

Examine the water samples at several points en-route the flow line of the water. Look at the clarity of the water between the flocks and study the shape and size of the flock.

- Observe the flock as it enters the flocculation basins. The flock should be small and well Dispersed throughout the flow.
- Tiny alum flock may be an indication that the chemical dose is too low. A ‘popcorn flake’ is a desirable flock. If the water has a milky appearance or a bluish tint, the alum dose is probably too high.
- As the flock moves through the flocculation basins the size of the flock should be increasing. If the size of the flock increases and then later starts to break up, the mixing intensity of the downstream flocculator may be too high. Try reducing the speed of these flocculators or increasing the coagulant dosage.

• Examine the settlement of the flock in the sedimentation basin. If a lot of floc is observed flowing over the laundering weirs the flock is too light for the detention time.
By increasing the chemical dose or adding a coagulant aid such as a polymer, a heavier, larger flock may be produced. The appearance of the fine flock particles washing over the effluent weir could be an indication of too much alum and the dose should be reduced. For precise evaluation you should make only one change at a time and evaluate the results.

A summary of coagulation-flocculation process problems; how to identify the causes of these problems and also how to go to correct the problems is tabulated below.

6.2.2.1.11Record 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.

6.2.2.1.12TABLE: COAGULATION-FLOCCULATION PROCESS TROUBLE SHOOTING.

Source water Quality changes	**Operator Actions**	**Possible process 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	**Operator Actions.**	**Possible process 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.	1. Adjust coagulant dosage. 2.Adjust flash mixer intensity (if possible) 3.Adjust alkalinity or pH 4.Change coagulant(s)

	4.Make appropriate process changes	
Flocculation Basic Flock Quality Changes	**Operator Actions**	**Possible process changes**
Flock formation	1.Observe flock condition in basin: a. Dispersion. B .Size and c .Flock strength (break up) 2. Evaluate overall process performance. 3. Perform jar tests. a. Evaluate flock 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.

6.2.2.1.13 Safety considerations

In the coagulation-flocculation processes, the operator will be exposed to a number of hazards such as:

- 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 familiar with general first aid practices such as mouth-to-mouth resuscitation, treatment of common physical injuries, and first aid for chemical exposure (chlorine).

For more details a reference may be made to “Safety Practices” in Chapter 19 of CPHEEO O&M Manual.

6.2.2.1.14 Start-up and Shutdown Procedures

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

This is not a routine operating procedure in most of the plants. These procedures generally happen when the plant is shut down for maintenance. In 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 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.
Open valves to start feeding coagulant chemicals and dilution make-up water.
Start chemical feeders.
Adjust chemical feeders as necessary.
7. Turn on the flash mixer at the appropriate time. You may have to wait until the tank or channel is full before turning on the flash mixer. Follow the manufacturer's instructions.
8. Start the sample pumps as soon as there is water at each sampling location. Allow sufficient flushing time before collecting any samples.
9. Start the flocculators as soon as the first basin is full of water.
10. Inspect mixing chamber and flocculation basin. Observe formation of flock and make necessary changes.
11. Remove any debris floating on the water surface.
12. Perform water quality analysis and make process adjustments as necessary.
13. Calibrate chemical feeders.
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.
Turn off chemical feeders. Shut off appropriate valves. Flush or clean chemical feed lines if necessary.
3. Shut down flash mixer and flocculates as water leaves each process.
4. Shut down sample pumps before water leaves sampling location.
5. Waste any water that has not been properly treated.
6. Lock out and tag appropriate electrical switches.
7. Dewater basins if necessary. Waste any water that has not been properly treated.
Note: Do not dewater below-ground basins without checking groundwater levels.
Close basin isolation gates or install stop-logs. Open basin drain valves
Be careful that the basin may float or collapse depending on ground water, soil or other conditions.
Good records of actions taken during start/ shut down operations will assist the operation conducting future shutdowns.

6.2.2.1.15 Laboratory Tests

Process control water quality indicators of importance in the operation of flocculation process include turbidity, alkalinity, chlorine demand, colour, pH, temperature, odour and appearance.

6.2.2.2SEDIMENTATION

6.2.2.2.1 Sedimentation Basins

The Basin can be divided into four zones.
Inlet zone

Settling zone
Sludge zone
Outlet zone
For more details a reference may be made to the Manual on “Water Supply and Treatment” published by Ministry of Urban Development. (1999 edition).

6.2.2. 2.2 Basin Types

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).

6.2.2. 2.3 Sludge Handling

(a) Sludge characteristics

Water treatment sludge’s are typically alum sludge’s, 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 are to be pumped, solids concentrations as high as 10% can be readily transported.
In horizontal flow sedimentation basins preceded by coagulation and flocculation, over 50% of the flock 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:
i) To prevent interference with the settling process (such as re-suspension of solids due to scouring).
ii) To prevent the sludge from becoming septic or providing an environment for the growth of microorganisms that create taste and odour problems.
iii) 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.

6.2.2. 2.4 Interaction with other Treatment Process

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 greater than 95% can be achieved. However, high sedimentation basin removal efficiencies may not always be the most 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 the need for sedimentation. In this case, coagulation-flocculation process is operated to produce a highly filterable pinpoint, which does not readily settle due to its small size; instead the pinpoint 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 you 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. In this case, the majority of the suspended particles and alum flock should be removed in the sedimentation basin.

6.2.2.2.5 Operating Procedures

From a water quality standpoint, filter effluent turbidity is a good indication of overall process performance. However one must monitor the performance of each of the individual water treatment processes, including sedimentation, in order to anticipate quality or performance changes. Normal operating conditions are considered to be conditions within the operating ranges of your plant, while abnormal conditions are unusual or difficult to handle conditions.

In normal operation of the sedimentation process one must monitor.

• Turbidity of the water entering and leaving the sedimentation basin and temperature of the entering water. Turbidity of the entering water indicates the flock or solids loading on the sedimentation process. Turbidity of the water leaving the basin reveals the effectiveness or efficiency of the sedimentation process. Low levels of turbidity are desirable to minimize the flock loading on the filter.

• Temperature of the water entering the sedimentation basin is important. As the water becomes colder, the particles will settle more slowly. To compensate for this change, you should perform jar tests and adjust the coagulant dosage to produce a heavier and thus a settling flock. Another possibility is to enforce longer detention times when water demand decreases.

• Visual checks of the sedimentation process should include observation of flock settling characteristics, distribution of flock at the basin inlet and clarity of settled water spilling over the launder weirs. An uneven distribution of flock or poorly settling flock may indicate that a raw water quality change has occurred or that the operational problems may develop.

6.2.2.2.6 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 flocks are visible beyond the basin inlet. When sedimentation is working well, the flock will only be visible for short distance. When the sedimentation is poor, the flock 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 (measured

as milligrams of solids per litre 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 launder weir. Flocks 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 effluent 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 the equipment is operated, since sludge removal discharge 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 a summary of sedimentation process problems and remedial measures are given in the following two Tables

6.2.2.2.7 Record Keeping

Maintain daily operations log of process performance and water quality characteristics and keep the following records:
1. Influent and effluent turbidity and influent 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).

6.2.2.2.8 TABLE: 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.Increasesampling 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.**
Flock setting characteristics Flock 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.

6.2.2.2.9 TABLE: SEDIMENTATION PROCESS TROUBLE SHOOTING.

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.		
Flock settling Rising or Floating Sludge	1.Observe flock settling characteristics: a. Dispersion b. size c. Settling rate 2. Evaluate overall process performance. 3. Perform jar tests. a. Assess flock 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.	1. Change coagulant. 2.Adjust coagulant dosage

	2. Perform jar test. 3. Verify process performance. Coagulation-flocculation process. 4.Make appropriate process changes (next column)	3. Adjust flash mixer/flocculator mixing intensity. 4.Change frequency of sludge removal (increase or decrease)
5.Uplow 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.

6.2.2.2.10 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 and 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. Fill sedimentation basin 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.

(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.
Shut off mechanical equipment and disconnect where appropriate.
Check that valves are in proper position.
4. Lock out electrical switches and equipment.
5. Dewater basin if necessary.

Be sure that the water table is not high enough to float the empty basin.
Open basin drain valves.
6. Grease and lubricate all gears, sprockets and mechanical moving parts which have been submerged immediately following dewatering to avoid seize up.

6.2.2.2.11 Equipment

(a) Types of support equipment – Operation and Maintenance

The operator will need to be thoroughly familiar with the operation and maintenance Instructions for each specific equipment. Flow meters and gauges. Valves.
Control Systems.

Water Quality monitors such as turbidity meters., Sludge removal equipment., sludge pumps., Sump pumps.

(b) Equipment Operation

Check the following:

1. Proper lubrication and operational status of each unit.

2. Excessive noise and vibration, overheating and leakage.

3. Pumps suction and discharge pressure.

Safety Considerations

(a) 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.

(b) Mechanical Equipment

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

(c) Open Surface water – filled structures

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

Valve and Pump Vaults, Sumps

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

For more details please refer to Chapter 19 - Safety Practices.

Corrosion Control

All metallic parts which are liable to corrosion must be protected. Please refer to Chapter 9, of Manual on “Water Supply and Treatment” (1999 edition) for detailed discussion on

Corrosion Control.

6.2.2.2.12 Preventive Maintenance

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

1. Keeping electric motors free of dirt and moisture.
2. Assuring good ventilation.
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.

6.2.2.2.13 Record Keeping

Maintain a daily operations log of process performance data and water quality characteristics. Accurate recording of the following items should be maintained.

1. Process water quality (turbidity and colour).
2. Processoperation(filtersinservice,filtrationrates,lossofhead,lengthoffilterruns, frequency of backwash, backwash rates, and UFRV-unit filter run volume).
3. Process water production (water processed, amount of backwash water used, and chemicals used).
4. Percentage of water production used to back wash filters.
5. Process equipment performance (types of equipment in operation, equipment adjustments, maintenance procedures performed, and equipment calibration).

6.2.2.2.14 TABLE. : SUMMARY OF ROUTINE FILTERATION 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. Adjust flash mixer/flocculator mixing intensity. Change filtration rate Back wash filter Change chlorine dosage 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 5,4,3,3)
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	Filter module	At least once per day or whenever backwashing occurs.	Change backwash rate. Change backwash cycle time.

water trough. Observe clarity of waste water.			Adjust surface wash rate or cycle time. Inspect filter media and support gravel for disturbance.
Check Filtration process and back wash equipment condition.			
Noise, Vibration, Leakage, Overheating	Various	Once per 8hour 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.

6.2.2.2.15 TABLE: 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. Performa 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 litters) 6. Start filter aid feed. 7. Change coagulant.
Sedimentation process Effluent quality changes		
Turbidity or flic carry over	1. Assess overall process performance.	Same as source water quality changes.

	2. Perform jar tests. 3. Make appropriate process 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.Replenixh 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.

6.2.2.2.16 -TABLE: 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*				
Per cent of water filtered						*No. of filters operating*				
Av. Time of wash-min						*Filters out per wash-min*				
						Shift				
						Operator				

6.2.2.2.17Start-up and Shutdown Procedures

(a)Routine Procedures

Most plants keep all filters on line except for backwash and in service except for maintenance. Filters are routinely taken off line for backwashing when the media becomes clogged with particulates,turbiditybreakthroughoccursordemandsforwaterarereduced.

(b) Implementation of Start-up and Shutdown Procedures

1. Filter check out procedures

- Check operational status of filter.
- Besurethatthefiltermediaandwashwatertroughsarecleanofalldebrissuch as leaves, twigs, and tools.
- Check and be sure that all access cover sand walk way gratings are in place.

- Makesurethattheprocessmonitoringequipmentsuchasheadlossandturbidity 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 the min to service.

The surface wash system should be activated just before the back wash 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 backwash cycle to permit proper settling of the filter media.

A filter wash should begin slowly for about one minute to permit purging (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 :(Ref. Fig.in next page)

Log length of filter run since last backwash. Close filter

in fluent valve (V-1).

Open drain valve (V-4).

Close filter effluent valve (V-5).

Start surface wash system (Open V-2). Slowly start

back washes 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).

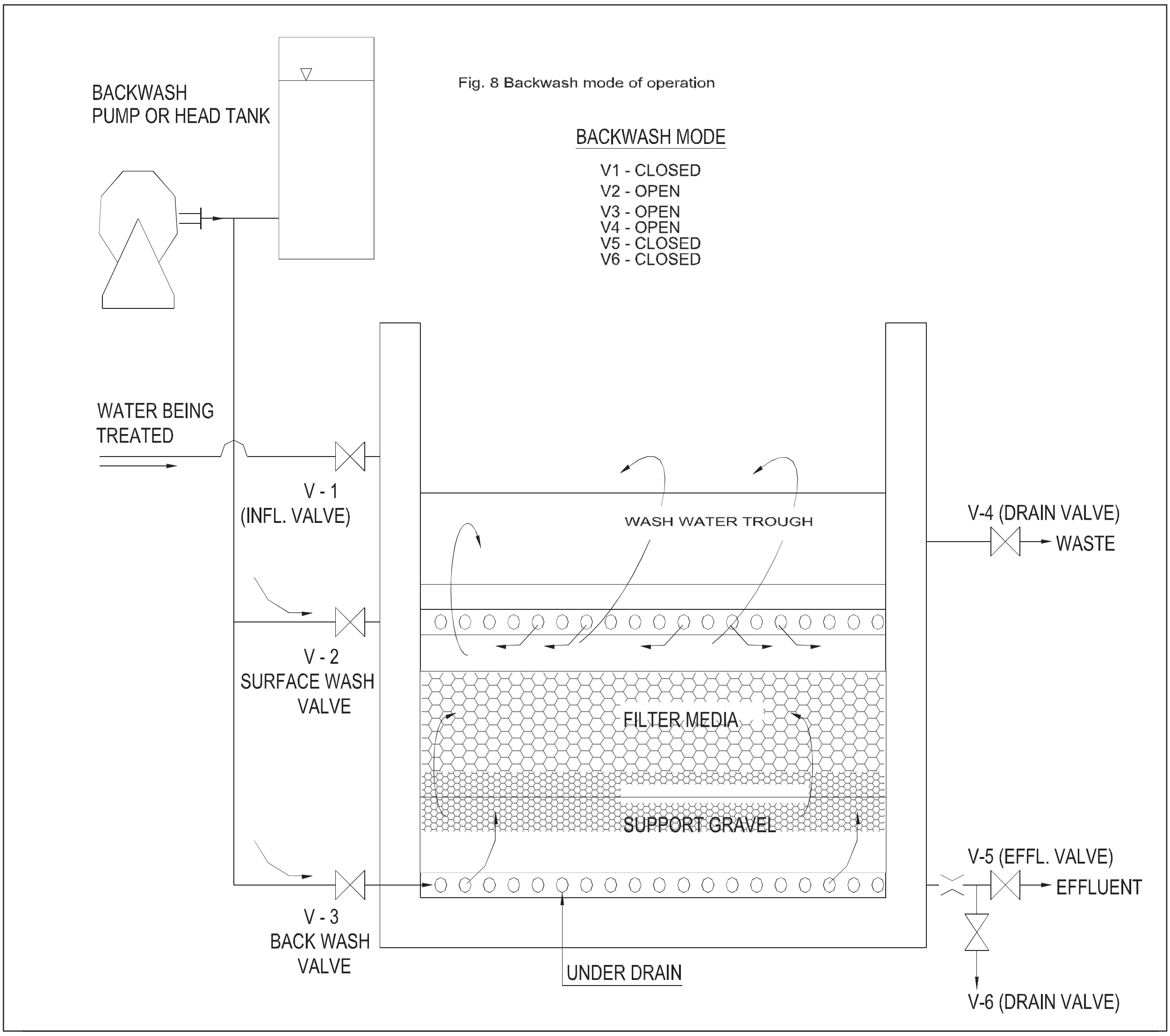
Log length of wash and the quantity of water used to clean filter.

(c) Filter Start-up 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.

d) Filter Shutdown Procedures

Remove filter from service by closing influent valve and closing effluent valve

Back wash filter.

If filter is to be out of service for a prolonged period ,drain water from filter to avoid algal growth.

Note status of filter in operations log.

6.2.2.2.18Support Equipment

The operator must be familiar 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 less and water level).
6. Mechanical and electrical filter control systems.

(b) Equipment Operation

Before starting a piece of mechanical equipment, such as aback wash pump, be sure that the unit has been serviced on schedule and its operational status is known.

After start up, always checks for excessive noise and vibrations, overheating, and leakage (water, lubricants).When in doubt about the performance of a piece of equipment, refers to manufacturer's instructions.

Periodic calibration and maintenance of the equipment is necessary

6.2.2.2.19Preventive Maintenance Procedures

Preventive maintenance programmes are to assure the continued satisfactory operation of treatment plant facilities by reducing the frequency of breakdown failures.

Routine maintenance functions 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, un- usual noise and vibrations or overheating.
- Maintaining proper lubrication and oil levels.
- Inspecting for alignment of sand 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.
- Verifyingcorrectoperationoffiltersandbackwashingcyclesbyobservation.
- Inspecting filter media condition (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 be

coming clogged due to media, corrosion or chemical deposits).

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 out and tag electrical switches and panels when servicing equipment.

(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 chemical spills(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. Only work in well ventilated structures(use air circulation fans). For more details

please refer CPHEEO O&M Manual Chapter19-'Safety Practices'

6.2.2.2.20AUGMENTATION OF RAPID SAND FILTRATION PLANT

Augmentation of an existing Rapid Sand Filtration Plant can be carried out by converting the conventional filtration process to Variable Declining Rate Filtration with dual media filter units. The filter unit will, however, require additional depth. Special precautions are required to strictly adopt the specifications of the two filter media as regards effective size and specific gravity. During operation a special watch has to be kept to avoid intermixing of the two media.

6.2.2.2.21 ALGAL CONTROL

Note: Only a brief description of removal of algae is being given in order to help the operator to understand and take effective steps in operating and maintaining such plant processes *(Ref. CPHEEO O&M Manual p110-113).*For more details a reference may be made to the Manual of Water Supply and Treatment (Chapter 9).

INTRODUCTION

Algae are unicellular or multicellular 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 for treatment and production of potable water.

The algae encountered in water purification plants are Diatoms, Green Algae, Blue Green Algae and Algal Flagellates. Algae may be seen floating (plankton)in the form of blooms.

PROBLEMS CAUSED BY ALGAE

1. Many species of algae produce objectionable taste and odour due to characteristic oil secretions (Table 5.9). 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

Preventive Measures

Preventive measures can be taken to a limited extent by making environmental conditions unfavourable as explained in Chapter 9 on Manual for “Water Supply and Treatment” (1999 edition).

Control Measures

Adequate records of number, kind and location of algae becomes handy for algal growth control. Details are given in the Manual for “Water Supply and Treatment” (Chapter 9).*Algaecide* dose used should be harmless to humans, have no effect on water quality, should be in expensive and easy to apply. The most commonly used *algaecides* are copper sulphate and chlorine.

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 from15-45µm.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.

6.2.2.22 COPPER SULPHATE TREATMENT

Toxity and Dosage

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Copper Sulphate is toxictomany algae at comparatively low concentration, which is normally non-lethal to fishes and is relatively inexpensive. Dosage of copper sulphate lethal for algae is expressed in terms of concentration of $CuSO_4.5H_2O$ inmg./l. The quantity of copper sulphate required has to be calculated on the basis of the type of algae present, period of its multiplication and volume of reservoir. Temperature, alkalinity and carbon dioxide content of water also influence dosage. Low temperature, high alkalinity and low carbon dioxide decrease effectiveness of copper sulphate.

The mean recommended dose is 0.3mg. /l; this dose may be used even in absence of laboratory control.

Points to be taken into account while formulating copper sulphate dosage

The dose of copper sulphate, to be added to unknown water depth, has to be calculated by considering 4.5metres depth of water as algae congregate in the upper zone only.

For alkali e water (alkalinity above 50mg./l as calcium carbonate) the dose should be based on surface area rather than volume of water as *algaecide* will be precipitated as copper bicarbonate before it can diffuse to lower depths. This difficulty can be overcome by scattering fine granular copper sulphate over the water surface .Water of intermediate alkalinity may be treated on volume basis.Copper Sulphate is not effective at pH 8.5, hence before copper sulphate treatment pH Should be adjusted to maximise result .Laboratory tests should be performed ensuring that copper content is within permissible limit in water supplied (i.e.0.05mg/l). Depletion of dissolved oxygen due to de composition of dead algae and clogging of gills of fish by dead algae clusters can be avoided by starting application of copper sulphate at the dams or reservoirs, which gives ample time to fishes to get away from treatment sites.

Method of Application

Several methods of applying copper sulphate are available:

1. *General practice: a* bag containing required amount of copper sulphate crystals is hung at the point of entry of raw water in to treatment plant.
2. *Burl p bag Method:* Required quantity of crushed copper sulphate crystals is placed in a cloth bag, which is dragged under the water surface by using about.
3. *Box Method:* Perforated wooden box containing copper sulphate crystals is supported in such a way that the depth of submergence can be varied as required at the point of entry of raw water in to the treatment plant. The box should be filled to a point above Water level .Copper sulphate crystals are dissolved by water flowing through the box. Dose of copper sulphate can be controlled by raising or lowering the box.
4. *Spray Method:*0.5-1% copper sulphate solution may be sprayed over the surface of water by conventional spraying equipment.
5. *Blower Method:* Large quantities of copper sulphate may be distributed over large reservoirs or lakes by using blower fitted motor boats. Finely granulated copper sulphate is fed into air entering the blower from a hopper fitted with a control valve.

6.2.2.2.23 CLORINE TREATMENT

General

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 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 run and facilitating filter washing.

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 are liberated which may lead to development of odour and colour and taste. Occasionally these oils as well as organic matter of dead algae may combine with chlorine to form intensified odour 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. A 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.

Chlorine Treatment vs. Copper Sulphate Treatment

Chlorination is preferred over copper sulphate treatment in certain conditions, which are as follows:

1. Copper Sulphate cannot be used when the application is too close to pipeline, as copper will plate out on metal thus becoming inactive.
2. Copper sulphate cannot be used to prevent algal growth in coagulant basin, as it will be immediately thrown out of solution.
3. If adequate time (for proper precipitation of the added copper sulphate) is not available between copper sulphate treatment and supply of water, copper sulphate treatment should be avoided and chlorine treatment should be preferred.
4. Death and decay of algae imparts taste and odour to water. It also results in increase of organic matter, which supports proliferation of saprophytes (organisms growing on dead organic matter) resulting in lowering of oxygen content of water. Breakpoint pre-chlorination helps in removal of taste and odour, also assists in coagulation and controls growth of saprophytes.
5. Certain algae are resistant to copper sulphate treatment.

6.2.2.2.24 O&M of Iron Removal Plants (Ref. CPHEEO O&M Manual p115-117)

Two types of such plants are described below:

Compact type plant

The process comprises of

i) Spray Aeration through a grid of pipes to flush out CO_2, H_2S and to improve pH level.

ii) Trickling of aerated water through a contact catalytic media viz., limestone of 20 mm size or a combination of MnO_2 (Manganese dioxide) and lime; or hard coke, MnO_2 and limestone.

iii) Sedimentation.

iv)Filtration through Rapid Gravity Filter.

v) Disinfection.

The structure consists of ordinary masonry or concrete. The aerator with contact media may be 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/d/m2. Filter media shall consist of sand with effective size
0.5-0.7 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. Flock 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 top sand 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 flocks are different from those of surface (river) water flocks.

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:

I) Dosing of sodium aluminate 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.

ii) Injection of compressed air for oxidation of dissolved iron.

iii) Thorough mixing of raw water, sodium aluminate 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.

iv) 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).

v) 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.

vi) 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 MnO_2 (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.

6.2.2.25Specific Treatment Technologies (Arsenic & Fluoride removal methods)

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

(a) Chemical precipitation

(b) Adsorption

(c) Membrane processes
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.

CHAPTER - 7

DISINFECTION OF WATER

7.1 INTRODUCTION

Drinking water is disinfected to kill bacteria, viruses and parasites, which may be in the water and may cause illness and disease. Many different diseases are spread by contaminated drinking water, including *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 supply pipes, or storage reservoirs are contaminated by animal wastes or human sewage.

In general, surface waters such as lakes and streams are more likely to contain disease-causing organisms than groundwater. Deep wells are safer than shallow wells. In fact, shallow dug wells are often as contaminated as lakes or streams.

When should we disinfect drinking water?

We should disinfect drinking water if:

- community has been issued a boil water advisory;
- using water directly from a stream, lake or shallow well;
- Lab tests of water show that it contains "faecal coli forms";
- A flood, earthquake or other disaster has disrupted community water supply;
- are 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.

7.2 DISINFECTION OF RURAL WATER SUPPLY SCHEME

The disinfection of potable water is almost universally accomplished by the use of gaseous chlorine or chlorine compounds, because of the limitations of other procedures, for example ozone, ultraviolet light, chlorine dioxide etc. Chlorine is easy to apply, measure and control. It persists reasonably well and it is relatively inexpensive

7.2.1 OBJECTIVE OF 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 5mg/l. With chlorine treatment essential oils present in algae are liberated which may lead to development of odour and colour and taste. Occasionally these oils as well as organic matter of dead algae may combine with chlorine to form intensified odour 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.

7.2.2 METHODS OF APPLICATION OF CHLORINE

Disinfection is carried out by applying chlorine or chlorine compounds. The methods of application are as follows:
1. Preparing weak solution by bleaching powder, HTH etc.
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.
vi) The precipitates of calcium hydroxide settles at the bottom of the tank. The supernatant water, which contains OCl

7.2.2.1 DISINFECTION BY BLEACHING POWDER

i) The concentrated solution of bleaching powder is prepared in one or two tanks of capacity suitable for 24 hours requirement.
ii) The tank inside should be of glazed tiles or stoneware and should be covered.
iii) 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.
iv) Water is sprinkled on the powder through a perforated pipe above this perforated slab. The solution of bleaching powder & water now enters the tank.
v) 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.

7.2.2.2 DOSING OF SOLUTION

i) 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 micrometre 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 waste precipitates at the bottom of tanks are taken out occasionally by scour valve.
ii) The dose has to be monitored properly, depending on the desired residual chlorine required in clear water reservoir.

7.2.2.3 PRECAUTIONS

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

7.2.3 ELECTROCHLORINATOR

PRINCIPLE OF OPERATION OF ELECTROCHLORINATOR

Chlorine is instantly produced by electrolysing 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.

7.2.3.1 DESCRIPTION OF ELECTROCHLORINATOR

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.

7.2.3.2 OPERATION OF ELECTROCHLORINATOR

i) 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/ cm 2As soon as the outflow from surge tank starts, electrical operation through rectifier is to be started.

ii) 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.

iii) 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 mins.
Simultaneously, potentiometer is to be operated in anticlockwise direction slowly to set to "zero" position. Now AC main MCB is put to "OFF" position.

iv) 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.

v) 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 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.

vi) 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 to
25 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.

vii) Normally 4.5 kg. of common salt (NaCl) is required to produce 1 Kg. of chlorine with4.5 kWh power.

7.2.3.3 MAINTENANCE OF ELECTROCHLORINATOR

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, at first, 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, if choked with 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.

7.2.4 Other Disinfectant

The other chemical based disinfectants generally in used as disinfectant in water supply schemes are ionized silver coating, halogens, ozone, 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.

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.

These methods are described in the CPHEEO manual chapter 6.

CHAPTER - 8

STORAGE OF WATER

(Reservoirs including service reservoirs)

8.1 INTRODUCTION

The main function of Reservoirs and Service Reservoirs (SR) is to cater for daily demands and especially peak demands of water. Operators/managers must be concerned with 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.

8.1.1 NORMAL PROCEDURES FOR OPERATION OF SERVICE RESERVOIR (S.R.)

Service Reservoirs have to be operated as per the design requirements. Normally the service reservoirs are constructed 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.

In some systems reservoirs are allowed to float at the end of distribution system when pumps are used to pump directly into the distribution system and excess water flows into the SR. In such systems multiple pumps are used to cater to varying demand and pressures in the system.

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.

8.1.2 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/manager 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.

8.1.3 STORAGE LEVELS

Most of the distribution systems establish a pattern of levels for assuring the required supplies at the required pressures. A water usage curve over a 24 hour period should be prepared for each SR. It can be seen from the usage curve that the pattern varies not only during the different times of the day but also during different days of the week especially on week-ends, holidays and festivals. Demand pattern also changes during different times of the year depending on the weather conditions such as summer; winter etc. From the usage curve the operator can better anticipate and be ready for the expected high consumption periods. 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.

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. The operator should work out a program for compliance.

8.1.4 STORAGE CAPACITY

Capacity of storage reservoir at different levels can be calculated and charts or tables can be prepared and kept at the SR site. Proper functioning of water level indicators is required to read the water level in the SR and assess its capacity. 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. Automatic valves are used to prevent overflows from SR and maintain a constant level in the SR as long as the pressure in the distribution system is adequate. Often the pumps feeding into a SR are switched off or switched on as per the water levels in the SR. In some SRs advance warning alarms are provided to signal when water levels in SR are either too low or too high. The operator shall ensure that the automatic operations work as and when needed. Sometimes time clocks are often used to control the water coming into the reservoir. At some places the overflow is connected to the distribution system; in such cases some mechanism must be in place to indicate that the reservoir has started overflowing.

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

8.1.5 STORAGE LEVEL CONTROL

A simple system used to read and control the levels in SRs is a gauge/water level indicator. Whenever the SR reaches the maximum water level, the operator informs the pump house to stop pumping. In place of the traditional telephones, mobile phones or dedicated wireless units can also be used. Electrodes, ultrasonic signals or solid state electronic sensors are also used to sense the rise and fall in water levels and send signals to the pumps to be stopped or started through cables or wireless or radio frequencies. It is also desirable to have an indication of levels of SR in the pump house. Automation of level controls at SR s is to be attempted with caution since most of the authorities require only a small amount of instrumentation and control. It is desirable that only simple level control instruments are chosen keeping in view availability of skilled personnel. However, it is desirable that trained and qualified operators only are permitted to repair the instruments.

8.1.6 SAMPLING FOR WATER QUALITY

Water from all SRs should be regularly sampled especially once, before and after monsoon to determine the quality of water that enters and leaves the SR. Sampling data can help in setting up periodic cleaning of SR. Indicators that help to decide when the tank is due for cleaning is turbidity, excessive color, taste and odor. Water quality problems may be of microbiological type which could be caused by loss of residual chlorine due to bacterial contamination. Chemical water quality problems may also occur due to leaching from reservoir lining and coating for RCC and masonry tanks and due to corrosion of steel tanks. 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. Sometimes poor design, and improperly applied/and or cured coatings and linings may also cause water quality degradation. Proper investigation is required to find the reasons for water quality degradation determine the source of the problem and address the same. Wherever seasonal demands fall and the residual chlorine levels get depleted, it may be necessary to add additional chlorination facilities.

8.2 PLAN FOR O&M OF SERVICE RESERVOIRS

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.

8.2.1 PROCEDURES FOR OPERATIONS

The operational procedures inter-alia will contain:

• Design criteria for the reservoir such as: capacity in liters, size and depth of storage; size of piping of inlet, outlet, scour and overflow; sizes and locations of control valves of inlet, outlet and scour; source of feeding the reservoir; hours of pumping or gravity feeding into the reservoir; rate of flow into the reservoir; hours of supply from thereservoir 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.

• Structural drawing of the SR and the layout drawing 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 over flow 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.

• A spot map showing the location of the piping and valves. The map shall also indicate open or closed positions of valves to be operated. This map shall be preserved by glass cover or laminated to prevent unauthorized meddling

• 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 supplied.

• 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.

• Instruction for situations when valves cannot be operated due to some problems regarding authority to be informed and receive further instructions.

8.2.2 MAINTENANCE PROCEDURES

The maintenance procedures shall contain step by step procedure to cover every piece of equipment used in SRs such as valves and flow meters preferably following the procedures indicated in the manufacturers' catalogues.

(a) Valves

• All valves should be inspected and operated regularly.

• The manager shall specify frequency of inspection.

• A small amount of penetrating oil is poured down the spindle to lubricate packing gland and soften the packing.

• Valve spindles that develop leaks on turning 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.

b) Service Reservoirs

SRs have to be inspected regularly and the manager 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. 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.

8.3 CLEANING OF SERVICE 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.
- Draw the water from the SR till 200-300 mm water is left in the SR.
- Close the outlet valve so that no water will be used while the tank is being cleaned.
- Collect sample of water and silt/mud accumulated in the Tank and get the biological analysis and for presence of snails and worms. If snails and worms are found find the source and eliminate it.
- 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.
- Frequency of cleaning of SR depends on the extent of silting, development of bio films and results from water quality monitoring.

8.4 RECORDS AND REPORTS

8.4.1 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.

8.4.2 RECORDS TO BE KEPT ON THE OPERATIONS

Note the following:

• Water levels in the SRs (for all compartments) at hourly intervals.

• Time and relevant operation of control valves with time of opening and closure or throttling position of the valves.

• Hourly flow meter readings both on the inlets and outlets.

• Hourly residual chlorine readings of inflow water and outflow water.

• The man-hours spent on routine operations at the SR in previous year and the cost thereof.

8.4.3 MAINTENANCE RECORD

Maintain record on each of the following maintenance/repair works along with the cost of materials and labor.

• When the gland ropes of the valves at the SR were changed.

• When the spares of the valves were changed.

• When the manhole covers were changed/replaced.

• When the water level indicator was repaired or replaced.

• When the reservoir was last cleaned.

• When the out-fall drain for scour and overflow was last cleaned.

• When the ladder was changed. • When the structure of the reservoir was last repaired to attend to structural defects or arrest leakage.

• When the reservoir was last painted

• When the piping at the reservoir 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.

8.4.4 REPORTS

With the accumulation of all essential data a report can be prepared evaluating the O&M of the facility. The report can identify the deficiencies in the SR and its appurtenances and

CHAPTER - 9

Distribution system

9.1 OBJECTIVE

The overall objective of a distribution system is to deliver wholesome 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.

9.2 ISSUES CAUSING PROBLEMS IN THE DISTRIBUTION SYSTEM

9.2.1 INTERMITTENT SYSTEM

The distribution system is usually designed as a continuous system but often operated as an intermittent system. Intermittent supply creates doubts in the minds of the consumers about the reliability of water supply. This leads to limited use of the water supplied, which does not promote personal hygiene at times. 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.

9.2.2 NON-AVAILABILITY OF REQUIRED QUANTITY OF WATER

Failure of source or failure of power supply may cause reduced supplies. Normally, the distribution reservoirs are designed for filling in about 8 hours of pumping and whenever the power supply is affected 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.

902.3 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.

9.2.4 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.

9.2.5 UNAUTHORISED 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.

9.2.6 EXTENSION OF AREA OF DISTRIBUTION SYSTEM

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.

9.2.7 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 and reduced pressure and pollution of supplies

9.2.8 LACK OF RECORDS

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.

9.3 OPERATION SCHEDULE

9.3.1 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.

9.3.2 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.

9.3.3 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 analyse 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.

9.3.4 OPERATIONS IN OTHER THAN NORMAL CONDITIONS

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.

9.3.5 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.

9.3.6 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.

9.4 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.

9.5 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].

9.6 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.

9.7 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.

9.8 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.

9.9 CHLORINE RESIDUAL TESTING

A minimum chlorine residual of about 0.2 mg/l at the selected monitoring point 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.

9.10 Sample records to be maintained 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 corrosive water in the system,
- 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,
- 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 bacteriological samples are unwholesome,
- Record on carrying out repairs on the following
- The pipe line leaks or replacement of pipes.
- Change of gland ropes of the valves in distribution system.

- Replacement of parts.
- Replacement of manhole covers.
- Record on man hours spent on routine operations in the distribution system in the previous year and the cost thereof,
- Record on total cost of repairs and replacements in previous year along with breakup of material cost and labor cost with amount spent on outside agencies for repairs and replacements,
- 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 interconnections.

CHAPTER - 10

PUMPING MACHINERY

10.1 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.

100% standby pump sets can be provided when the discharge of the pumps are within 5000 lpm. If the discharge exceeds 5000 lpm, 50% standby may be adopted (2+1; 4+2; etc.). Maintaining 50% standby and operating two more pumps in parallel will have the following advantages.

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 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 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

10. 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

b) 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

10.2.1 TYPE OF PUMPS

Following types of pumps are used in water supply systems.

i) Centrifugal pumps

ii) Vertical turbine pumps

Oil lubricated

- Self-water (pumped water) lubricated
- Clear water lubricated

iii) Submersible pumps

- Vertical bore well type pump-motor set
- Mon bloc open well type pump-motor set

iv)Jet pumps

v) Reciprocating pumps

10.2.2 OPERATION OF THE PUMPS

10.2.2.1 IMPORTANT POINTS FOR OPERATION

Important points as follows shall be observed while operating the pumps.

(a) Dry running of the pumps should be avoided.

Important points as follows 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. Characteristics of the pump.

(c) Pumps should be operated only within the recommended range on the head-discharge Characteristics of the pump.

- If pump is operated at point away from duty point, the pump efficiency normally reduces.

- 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, in 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 to stabilize 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.

k) If any undue vibration or noise is noticed, the pump should be stopped immediately and cause for vibration or noise be checked and rectified.

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

(m) 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.

10.2.2.2 UNDESIRABLE OPERATIONS

Following undesirable operations should be avoided.

i) 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.

ii) 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.

iii) 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.

IV) 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.

V) 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 and pitting similar to operation on higher suction lift. The strainers and foot valves should be periodically cleaned particularly during monsoon.

VI) 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.

10.2.3 STARTING THE PUMPS

10.2.3.1 Checks before starting

Following points should be checked before starting the pump.

- Power is available in all 3 phases.
- 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.

. 10.2.4 STOPPING THE PUMP

10.2.4.1 Stopping the Pump under Normal Condition

Steps to be followed for stopping a pump of low and medium specific speed are as follows:
i) Close the delivery valve gradually (sudden or fast closing should not be resorted to, which can give rise to water hammer pressures).
ii) Switch off the motor.
iii) Open the air vent in case of V.T. and submersible pump.
iv) Stop lubricating oil or clear water supply in case of oil lubricated or clear water lubricated VT pump as applicable

10.2.4.2 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.

i) Close all delivery valves on delivery piping of pumps if necessary, manually as actuators can not be operated due to non-availability of power.

ii) Check and ensure that all breakers and starters are in open condition i.e. off-position.

iii) All switches and breakers shall be operated to open i.e. off-position.

iv) 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.

v) Information about power failure should be given to all concerned, particularly to upstream pumping station to stop pumping so as to prevent overflow.

10.3.1.1 Daily Observations and Maintenance

(a) Daily Maintenance

• Clean the pump, motor and other accessories.

• Check coupling bushes/rubber spider.

• Check stuffing box, gland etc.

(b) 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.

i) Changes in sound of running pump and motor

ii) Abrupt changes in bearing temperature.

iii) Oil leakage from bearings

iv) Leakage from stuffing box or mechanical seal

v) Changes in voltage

vi) Changes in current

vii) Changes in vacuum gauge and pressure gauge readings

viii) Sparks or leakage current in motor, starter, switch-gears, cable etc

ix) Overheating of motor, starter, switch gear, cable etc.

(c) Record of operations and observations

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

i) Timings when the pumps are started operated and stopped during 24 hours. ii) Voltage in all three phases.

iii) Current drawn by each pump-motor set and total current drawn at the installation.

iv) Frequency.

v) Readings of vacuum and pressure gauges.

vi) Motor winding temperature.

vii) Bearing temperature for pump and motor.

viii) Water level in intake/sump.

ix) Flow meter reading.

x) Daily PF over 24 hour's duration.

xi) Any specific problem or event in the pumping installation or pumping system e.g. burst in pipeline, tripping or fault, power failure.

10.3.1.2 Monthly Maintenance

i) Check free movement of the gland of the stuffing box; check gland packing and replace if necessary.
ii) Clean and apply oil to the gland bolts.

iii) Inspect the mechanical seal for wear and replacement if necessary.
iv) Check condition of bearing oil and replace or top up if necessary.

10.3.1.3 Quarterly Maintenance

i) 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.

ii) 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.

iii) Tighten the foundation bolts and holding down bolts of pump and motor mounting on base plate or frame.

iv) Check vibration level with instruments if available; otherwise by observation.

v) Clean flow indicator, other instruments and appurtenances in the pump house.

10.3.1.4 Annual Inspections and Maintenance

A very thorough, critical inspection and maintenance should be performed once in a year.

Following items should be specifically attended.

i) 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.

ii) Clean bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in bearing housing.

iii) 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.

iv) Check stuffing box, glands, lantern ring, and mechanical seal and rectify if necessary.

v) Check clearances in wearing ring.

vi) Check impeller hubs and vane tips for any pitting or erosion.

vii) Check interior of volute, casing and diffuser for pitting, erosion, and rough surface.

viii) All vital instruments i.e. pressure gauge, vacuum gauge, ammeter, voltmeter,

10.3.2 MAINTENANCE SCHEDULE FOR MOTORS

10.3.2.1 Daily Maintenance

i) Clean external surface of motor.

ii) Examine earth connections and motor leads.

iii) 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).

iv) In case of oil ring lubricated bearing.

• Examine bearings to check whether oil rings are working.

• Note bearing temperature.

• Add oil if necessary.

V) Check for any abnormal Bearing noise.

10.3.2.2 Monthly Maintenance

i) Check belt tension. In case where this is excessive it should immediately be reduced.

ii) Blow dust from the motor.

iii) Examine oil in oil lubricated bearing for contamination by dust, grit, etc. (this can be judged from the colour of the oil).

iv) Check functioning and connections of anti-condensation heater (space heater).

Check insulation resistance by mongering.

10.3.2.3 Quarterly Maintenance

i) 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.

ii) 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.

iii) Check insulation resistance of the motor.

iv) Check tightness of cable gland, lug and connecting bolts.

v) Check and tighten foundation bolts and holding down bolts between motor and frame.

vi) Check vibration level with instrument if available; otherwise by observation.

10.3.2.4 Half Yearly Maintenance

i) Clean winding of motor, bake and varnish if necessary.

ii) In case of slip ring motors, check slip-rings for grooving or unusual wear, and polish with smooth polish paper if necessary.

10.3.2.5 Annual Inspections and Maintenance

i) 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.

ii) Clean bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in bearing housing.

iii) 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

iv) 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.

V) Check condition of stator, stamping, insulation, terminal box, fan etc.

vi) Check insulation resistance to earth and between phases of motors windings, control gear and wiring.

vii) Check air gaps.

viii) Check resistance of earth connections.

10.3.2.6 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 i) Details of motor, rating, model, class of duty, class of insulation, efficiency curve, type test result and type test certificate etc.

ii) Date of installation and commissioning.

iii) Addresses of manufacturer & dealer with phone & fax number and e-mail addresses.

iv) Brief details of monthly, quarterly, half yearly and annual maintenance and observations of inspections about insulation level, air gap etc.

v) Details of breakdown, repairs with fault diagnosis.

vi) Running hours at the time of major repairs.

10.3.5 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

1. Clean the external surface.

2. Check for any spark or leakage current.

3. Check for overheating.

b) Monthly

1. Blow the dust and clean internal components in the panel, breaker and starter.

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

3 Check relay setting.

c) Quarterly

1. Check all connections as per circuit diagram.

2. Check fixed and moving contacts and clean with smooth polish paper, if necessary.

3. Check oil level and condition of oil in oil tank. Replace the oil if carbon deposit in suspension is observed or color is black.

4 Check insulation resistances.

5 Check conditions of insulators.

d) Yearly

1 Check and carry out servicing of all components, thoroughly clean and reassemble.

2 Calibrate voltmeter, ammeter, frequency meter etc.

10.3.6 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 is also applicable to H.T. breakers and contactors. In addition, following important points shall be attended for H.T. breakers and contactors.

a) Monthly

1 Check spring charging mechanism and manual cranking arrangement for operation.

1 Clean all exposed insulators.

1 Check trip circuit and alarm circuit.

1 Check opening & closing timing of breaker.

b) Quarterly

1 Check control circuits including connections in marshalling boxes of breakers and transformer.

2 Check oil level in MOCB/LOCB/HT OCB and top up with tested oil.

*3. Yearly / Two yearly*1 Testing of protection relay with D.C. injection shall be carried out once in a year.

4 Servicing of HT breaker and contactor shall be carried out once in 2-3 years.

5 Check dielectric strength of oil in breaker and replace if necessary.

6 Check male & female contacts for any pitting and measure contact resistance.

10.3.7.1 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 earthing system etc.

a)Daily Observations and Maintenance

i) Check winding temperature and oil temperature in transformer and record. (For large transformers above 1000 kV, the temperature should be recorded hourly).

ii) Check leakages through CT/PT unit, transformer tank and HT/LT bushings.

iii) 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 Maintenance

i) Check oil level in transformer tank and top up if required. ii) Check relay contacts, cable termination, connections in marshalling box etc.

iii) Check operation of AB switch and DO fuse assembly.

iv) Clean radiators free from dust and scales.

v) 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.

vi) Inspect lightning arrestor and HT/LT bushing for cracks and dirt.

c) Quarterly Maintenance

i) Check dielectric strength of transformer oil and change or filter if necessary.

ii) Check insulation resistance of all equipment's in sub-station, continuity of earthlings and earth leads.

iii) Check operation of tap changing switch.

10.3.7.2 Pre-Monsoon and Post-Monsoon Checks and Maintenance

i) Check insulation resistance of transformer.

ii) Test transformer oil for dielectric strength, sludge etc. If necessary, filtration of oil shall be carried out before monsoon.

iii) Oil shall be tested for dielectric strength after monsoon.

a)Half-Yearly Maintenance

i) Check dielectric strength of transformer oil in CT/PT and filter or change oil if necessary.

ii) Check contact faces of AB switch and DO/HG fuse; apply petroleum jelly or grease to moving components of AB switch.

b) Annual Inspections and Maintenance

i) Measure resistance of earth pit. Resistance shall not exceed 1 ohm.

ii) Check bus bar connections, clean contact faces, change rusted nut bolts.

iii) Calibrate the protection relay for functioning. Check relay setting and correct if necessary.

iv) 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.

v) Test transformer oil for acidity test.

c) Special Maintenance

i) Painting of transformer tank and steel structure of sub-station equipment's shall be carried out after every two years. ii) 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 - 11

WATER METERS, INSTRUMENTATION TELEMETRY & SCADA

11.1 WATER METERS

11.1.1 INTRODUCTION

A water meter is a scientific instrument for accurate measurement of quantity of water distributed to the consumers. It also fulfils the need to know accurately the water produced and distributed.

It differs from flow meter in respect of the following points.

1. It is a quantity meter and not a flow rate meter.

2. Water meter is a mechanical device whereas flow meter may be a mechanical or an electronic device

3. Water meter is always specified in two accuracies i.e. lower range and upper range accuracies whereas a flow meters it is specified in a single range accuracy.

4. The upper range and lower range accuracies are 2% and 5% of the actual quantity respectively for the water meter whereas it is variable for flow meter as per the customer's requirement.

5. Importance is not given for repeatability and linearity in the case of water meter whereas importance is given in the case of flow 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.

11.1.2 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:

1. Water meter has to be selected according to the flow to be measured and not necessarily to suit a certain size of water main.

2. The maximum flow shall not exceed the maximum flow rating.

3. The nominal flow shall not be greater than the nominal flow rating.

4. The minimum flow to be measured shall be within the minimum starting flow of the meter.

5. Low head loss, long operating flow range, less bulky and robust meter shall be preferred.

11.1.3 INSTALLATION OF WATER METERS

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

1. 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.

2. 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 observed.

3. 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.

4. 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.

5. 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.

6. 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.

7. The protective lid should normally be kept closed and should be opened only for reading the dial.

8. 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.

9. 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.

10. 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.

11. Where intermittent supply is likely to be encountered the meter may be provided with a suitable air valve before the meter in order to reduce inaccuracy and to protect the meter from being damaged. At higher altitude, if meter is installed as above the problem will be eliminated.

11.1.4 TESTING AND CALIBRATION OF WATER METERS

1. The testing & calibration of a water meter is essential before putting it into use as it is a statutory requirement. It is also essential to test it periodically in order to ascertain its performance as during the course of meter working it is likely that its accuracy of measurement may deteriorate beyond acceptable limits.

2. A meter suspected to be malfunctioning is also tested for it's 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 it's 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. (1) Lower measurable limit in which +5% accuracy from minimum flow to transitional flow (exclusive) and (2) Upper measurable limit in which +2% accuracy from transitional flow (inclusive) to maximum flow.

11.1.5 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.

Preventive maintenance:-

1. Proper handling, storage and transportation of water meters.
2. To clean the dirt box or strainer wherever installed.
3. To replace the gaskets, if any
4. To clean the chamber in which the meter is installed and keep free from flooding, & seepage.
5. To remove the meter for further internal repair/replacement if it does not show correct reading pattern.

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.

1. Disassembling of water meters including strainer, measuring unit, regulator, registering device, etc.
2. Clean all disassembled spare parts in detergent solution in warm water.
3. Inspect the cleaned parts and replace worn parts and gaskets, if any.
4. Inspect the meter body spur threads and cover threads.
5. Inspect the sealing surface on meter body and paint the meter body, if necessary.
6. Inspect the vane wheel shaft pinion, bearing & pivot.
7. Inspect the vane wheel chamber.
8. Reassemble the water meter properly after reconditioning.
9. 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.

11.1.6 PREVENTION OF TAMPERING OF WATER METERS

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

1. 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.
2. The water meters must be sealed properly.
3. The water meters shall not allow reversible flow; it should register flow in forward directions only.
4. The water meter dials should be easily readable without confusions.
5. The lid, glass of water meters must be made up of tough materials as per IS 779 and shall be replaced timely.
6. The wiper or dial as far as possible is avoided.

7. 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. 8 . Periodical inspection/checking at site is essential to ensure the proper working of meter. 9 . Special sealing arrangements may be necessary and provided for bulk meters whereby unauthorized removal of the meter from the connection can be detected. Inspiret of 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.

11.1.7 AUTOMATIC WATER METERING SYSTEMS

Water meter is a cash register of a water supply authority. 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 favourable 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. Often access to these meters is also obstructed when these meters are installed in the consumers' premises. Sometimes manual work is involved for opening the chamber covers. Some consumers connect their electrical earth terminal to water utility pipe which endangers the safety of meter reader. If during the meter reading visit the consumer premises are not accessible the meter reader will have to visit it again which increases the cost of meter reading.`

The solution to above difficulties is to install automatic system to read meters and process the results by computer. Because of development in integrated circuit technology and low powered radio trans receivers this system to some extent is simplified.

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

1. Manual entry into meter books.

2. Manual entry into portable hand held entry terminals or recorders.

3. Direct electronic entry from meter registers either into portable data terminals or display units from which readings are transcribed in the field.

4. Telemetry link through radio, telephone.

11.1.8 RELEVANT NATIONAL & INTERNATIONAL STANDARDS

1. IS 779-1994: Water meters (Domestic type) – Specification (Sixth revision)

2. IS 2373-1981: Specifications for water meters (Bulk type) (Third revision)

3. 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

5. 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

11.2 INSTRUMENTATION

11.2.1 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.

A. Direct Method

B. Inferential Method

11.2.2 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.

A. Manometers

B. Elastic Pressure Transducer

C. Electrical Pressure Transducer

11.2.3 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:

I) A capacitor should be firmly fixed to a base.

ii) Cable lugs of appropriate size should be used.

iii) 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 another spanner to avoid damage to or breakage of terminal bushings and leakage of oil.

iv) To avoid damage to the bushing, a cable gland should always be used and it should be firmly fixed to the cable-entry hole.

vi) 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.

vii) 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.

viii) Ensure that the cables, fuses and switchgear are of adequate ratings.

11.2.3.1 Operation and Maintenance of Capacitors

I) 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.

ii) Frequent switching of the capacitor should be avoided. There should always be an interval of about 60 seconds between any two switching operations.

iii) 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.

iv) Leakage or breakage should be rectified immediately. Care should be taken that no appreciable quantity of imp- regnant has leaked out.

v) 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.
vi) Replace capacitor if bulging is observed.

11.2.4 LIFTING EQUIPMENT

Relevant points in the maintenance schedule as follows shall be applicable for lifting equipment's, depending on the type of lifting equipment i.e. chain pulley block, monorail travelling trolley and chain pulley block), manually operated overhead crane and electrically operated travelling crane.

11.2.4.2 MAINTENANCE OF LIFTING EQUIPMENT

Quarterly: -
-Check oil level in gear box and top up if required.
- Check for undue noise and vibration.
- Lubricate bearings and gear trains as applicable.
- Check insulation resistance of motors.

Half yearly:
- Clean limit switches.
- Clean all electrical contacts.

Yearly:
- Change oil in gear box.

Conduct load test of crane for rated load or at least for maximum load required to be handled. All fast moving components which are likely to wear should be thoroughly inspected once in a year and if necessary shall be replaced.

11.2.5 WATER HAMMER CONTROL DEVICES

are 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 are as follows:
• Surge tank
• One-way surge tank
• Air vessel (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 :

11.2.5.1 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.

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.

11.2.5.2 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.

11.2.5.3 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.

11.3 TELEMETRY AND SCADA SYSTEMS

11.3.1 MANUAL MONITORING

Normally the Managers of O&M of water utilities 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 manager 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.

11.3.2 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 a 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 fibre- 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.

11.3.2.1 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.

11.3.2.2 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.

11.3.3 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.

11.3.4 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 behaviour 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.

CHAPTER - 12

DRINKING WATER QUALITY MONITORING AND SURVEILLANCE

12.1 INTRODUCTION

Drinking water quality monitoring and surveillance is the continuous monitoring of public health along with vigilant assessment and control of safe potable water supply.

12.2 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 agrochemical contamination increasingly affect the quality of water resources. Moreover, infant mortality, mostly from diarrhoeal 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.

12.3 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 litre (mg/l) these terms are used to express the concentrations of dissolved or suspended matter in water. The parts per million (ppm) is a weight to weight or volume to volume relationship. Except in highly mineralized water, this quantity would be same as milligram per litre. This is preferable, since it indicates how it is determined in the laboratory.

pH of water 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.

Toxic is harmful, destructive or deadly poisonous.

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 beings and animals, but also occasionally found elsewhere. Used to indicate presence of faecal 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.

12.4 WATER SUPPLY AND SURVEILLANCE AGENCIES

Water supply agency 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.

12.5 PLANNING AND IMPLEMENTATION

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

12.5.1 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.

12.3.6 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 them, 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 climatological conditions• Communication and transport facilities available.

12.7 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.

12.8 SUPPORT STRUCTURE

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

12.8.1 COMMUNITY BASED MONITORING AND SURVEILLANCE

Community participation is an essential component of the monitoring and surveillance framework. 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 concern 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.

12.9 SURVEILLANCE ACTION

Surveillance action comprise of:

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

12.10 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.

12.10.1 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.

12.10.2 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 pinpoint target areas for remedial action, required to protect and improve the water supply system.

12.10.3 SANITARY INSPECTION REPORT

The sanitary inspection report shall cover the following:

1. Identify potential sources and points of contamination of the water supply.

2. Quantify the hazards attributed to the source and supply.

3. Provide a clear, graphical means of explaining the hazards to the operator/user.

4. Provide clear recommendations for taking remedial actions, to protect and improve the supply.

5. Provide basic data for use in systematic, strategic planning for improvement Moreover inspection report should not be restricted to water quality but should take into account other service condition such as coverage, cost, condition and quantity. Such surveys are important form the point of view of operation and maintenance. Suggested inspection forms for different water sources.

12.10.4 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:

1. Prior knowledge of source, and type of water supply; and map of distribution system.

2. Notify the visit in advance, where the assistance of community members is needed.

3. Carry prescribed forms and necessary accessories, like sample bottle, sample carry box, analysis kit etc.

4. Verify basic data with community.

5. Interview community members for drinking water supply service.

6. Verify information gathered by observation during survey.

7. Inspection and water sampling should not be haphazard, should follow specific guideline.

8. Water samples should be analyzed immediately for residual chlorine and thermo tolerant coliform, or transported quickly to laboratory in iced boxes.

9. Complete the sanitary report on site, and send it immediately to appropriate authority for follow-up remedial action if necessary.

10. Undertake appropriate small repairs at the time of survey in remote areas such as washer changing for leaking taps.

11. For pictorial forms, each risk point should be circled and given to member of water committee for follow-up action.

12.11 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 physicochemical 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, May

12.12 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.

12.12.1 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.

12.12.1.2 QUANTITY

Along with quality, quantity 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 be not be safe and affect the public health.

12.13 USE OF FIELD WATER TESTING KIT(FTK)

The field water testing kit developed by TWAD BOARD 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 7th and 8th 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.

1. Sampling procedures.
2. Testing procedures.
3. Reporting.

I. SAMPLING PROCEDURE:

The source from where water is collected should be in regular use. Before sampling, the source should be flushed adequately. For hand pump sources, before collecting the water, the water sould be pumped and wasted 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

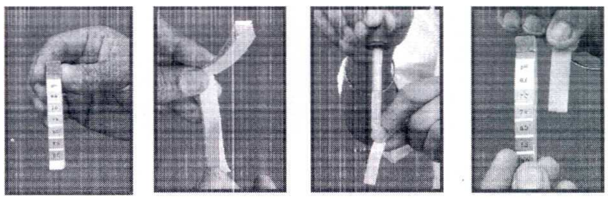
Write the field code number (sample ID) on the container. The field code number and related source details should be separately recorded in a note book.

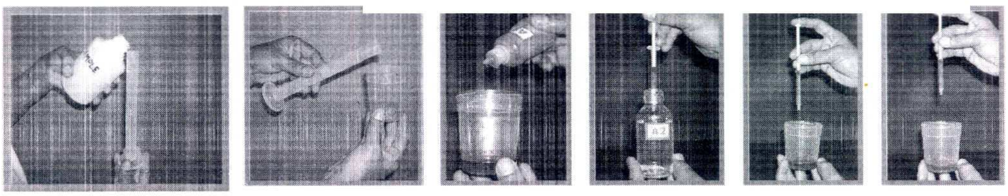
The testing of sample should be completed within 12 hrs. from the time of collection.

II. WATER TESTING PROEDURE

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.



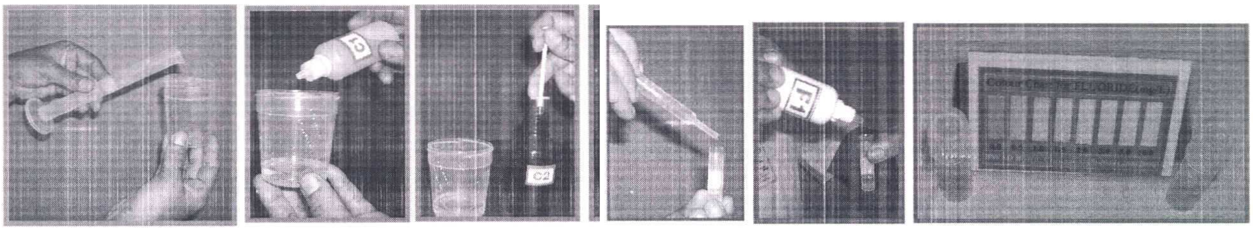


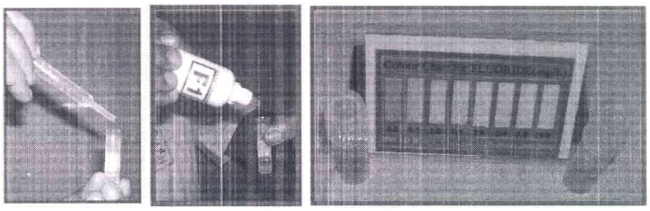
5.Alkalinity: Using the measuring cylinder, measure 20 ml of water sample and pour it into the clean titration cup. Add 5 drops of '**A1**liquid. The water turns ***bluish green.*** Using the '1 mL syringe' provided in the kit, add 'A2' liquid. At the end point, the color of water changes into **yellow** 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



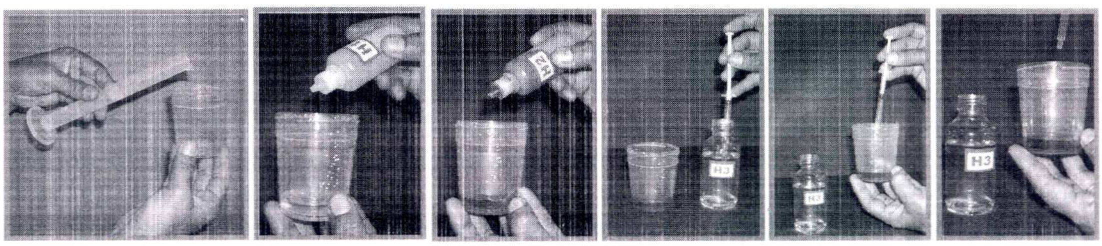


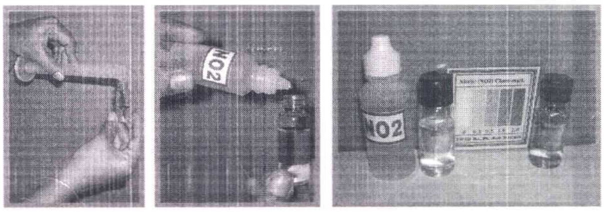
8. **Total Dissolved Solids (TDS):** The approximate value of TDS can be arrived at by the following calculation:

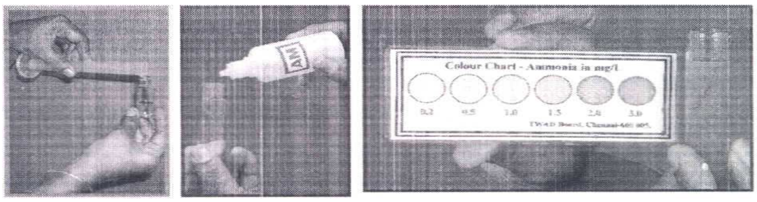
Calculation: TDS mg/L = (Alkalinity + Hardness + Chloride) x 1.2

9. **Fluoride:** In the 1.5 mL polypropylene tube, add 1.0 mL sample water. Add 5 drops of **'FI'** 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 'AM' liquid. Gently shake the bottle. If there is no ammonia, the color will not change. If ammonia is present, the water turns Compare the ‘‘yellow colour developed with the **'ammonia chart'** provided and record the ammonia value.

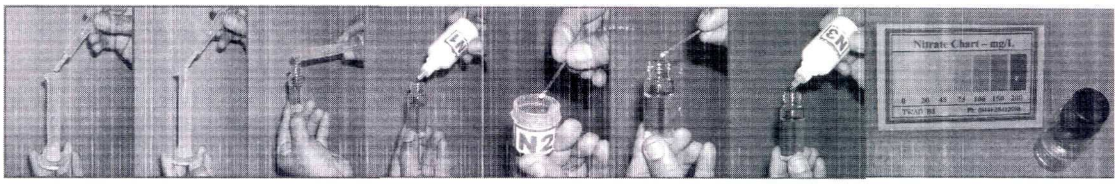




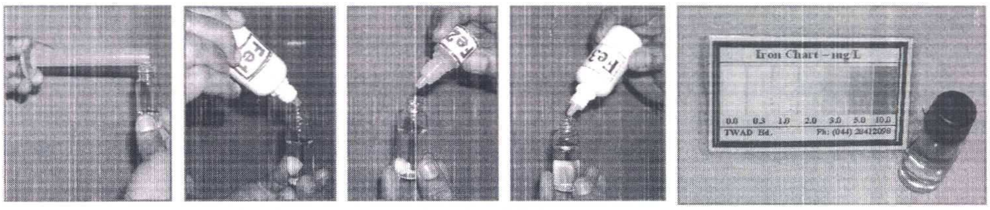


11. **Nitrite:** In the small glass bottle given, take 10 ml of water sample. Add 5 drops of **'N02'** liquid. Gently shake the bottle. If there is no nitrite, the color will not change. If nitrite is present, the color of water will change into pink. Compare the 'pink' color with the **'Nitrite (N02)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

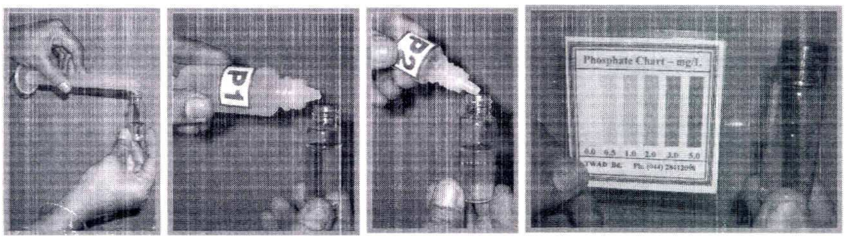
12**<u>Nitrate</u>:**In the 10 mL measuring cylinder, take 1 mL of water sample. Add 9 mL distilled/bottled/mineral water and make up to 10 mL. Transfer this to the 10 mL glass bottle. Add 5 drops of **'Nl'.** Add a small pinch of **'N2'.** Mix. Add 5 drops of **'N3'.** Wait for 2 minutes. If there is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



<u>Iron</u>: 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



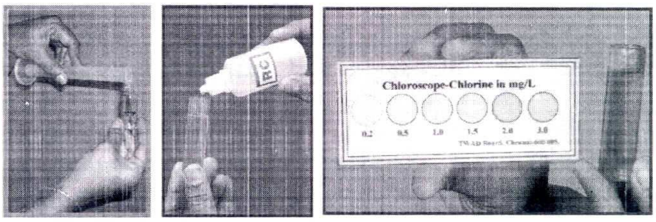
14. **Phosphate:** In the small glass bottle given, take 10 ml of water sample. Add 5 drops of **'Pl'** liquid. Gently shake the bottle. Then add 1 drop of **'P2'** liquid. Again gently shake. If there is no phosphate, the color will not change. If phosphate is present, the color of water will change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



Sample ID:

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 CaCO.., (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 is **Chemically POTABLE / NON POTABLE**

CHAPTER - 13

WATER REVENUE (BILLIMG & COLLECTION)

13.1 INTRODUCTION

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

13.2 TARIFF FIXATION

The water charges to be fixed by the utility take into account the ability of the system to meet the expenditure on the following heads. (i.e.)

- Operating Cost (excluding establishment cost).
- Establishment Cost.
- Depreciation.
- Debt Services & Doubtful Charges.
- Asset replacement fund.

Tariff structure should be fixed and revised periodically. Automatic increase of tariff periodically on index basis can also be adopted. Where the same authority also provides sewerage system, charges for this can also supply through Public stand post, may be charged and also be included as a percentage of the water charges.

13.3 CATEGORIES OF CONSUMERS

The various categories of consumers are:

I) Domestic,

ii) Commercial (Business entities, Hotels, Industries etc.),

iii) Government Authorities,

IV) Partly Commercial,

v) Bulk Consumers.

Among the five categories, the domestic consumers are the privileged class of people in terms of supply of water and collection of taxes mainly because they use water for their healthy existence. The other categories of consumers largely use water while carrying out commercial business activities. Therefore, the distribution of cost incurred on the maintenance of such system to each class of consumers 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.

13.4 METHODS OF WATER CHARGES

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

A. Metered System:

1. Actual consumption of water.
2. Minimum fixed charge.

B. Non-Metered System:

• Fixed charge per house per month.

• Fixed charge per family per month.

• Fixed charge per tap per month.

• Percentage of rateable value of the property.

The various stages in the Cycle of Water Billing Process are:

• Data gathering (Meter reading in case of metered billing).

• Generation of bill based on this data.

• Distribution of bill to consumer.

• Payment of the Bill by the Consumer.

• Sending the receipt details to billing section.

• Related accounting.

Irrespective of the basis of the billing-metered/unmetered the billing system needs three major data base:

• Master Data - This is the data, which needs to be entered only once when the consumer/connection is added into the database. This data is relatively static in nature and does not change periodically. Various data items, which need to be stored, (depending on the type of water charges) are:

Consumer number, name of consumer, address, type of use, type of consumer, tap size, data of connection, details of feeder line, locality, house number, water connection number, number of taps, number of families, meter make, meter number, first reading, ownership of meter, deposit amount etc.

• Data for each billing cycle - This data will be entered for every consumer for every cycle and will be used for calculating the demand of that billing cycle. Various data items which need to be stored are-

Consumer number, data of meter reading/period for which billed, status of the connection and any changes in master data etc.

• Receipt Data - This data will be the data related to the payments made by the consumer against the bill issued. This data will be entered on daily basis irrespective of the billing frequency. Various data items which need to be stored are:

Consumer number, date of receipt, receipt number, details of the collection center, cash/cheque (If cheque - cheque no, bank branch) Part payment/ ad hock payment/ deposit, account head for posting etc.

13.5.1 DATA GATHERING

For better administrative control over the complete billing process the city/town is divided into various zones/sections geographically or as per the distribution networks (service reservoir wise). It is observed that the cities already have ward numbers or localities which can be used as they are but if the billing is as per the distribution network the billing system can provide very important feedback as far as water/revenue losses are concerned (unaccounted for water - UFW).

These zones are further divided into smaller area (Wards) for better control. The person responsible for gathering data from these areas is the meter reader/ward clerk. In case of metered system the number of consumers who can be handled by one-meter reader will depend upon the geographical spread of the area and other office jobs to be performed by the person. In many utilities the range varies from 800 to 1500 consumers per month. In case of unmetered system the number can be increased. The prime responsibility of meter reader/meter clerk will be to gather all the data related to the water connections in the given area, to collect all the data related to new connections/ disconnection or any change in the category.

13.5.2 GENERATION OF BILLS

The water rates/tariff structure may have one or more aspects from the following - consumption based, flat rate, minimum charges, fixed charges, average consumption based etc.

Depending on the data gathered the demand for a particular billing period is calculated. The outstanding amount is worked out on the basis of details of payments received. The charges for delayed payments or amounts not paid are calculated as per the rules. The bills are generated area-wise.

13.5.3 DISTRIBUTION OF BILLS TO CONSUMER

The distribution of bills can be done using any one of the following :

I) By post or courier,

- By persons specially appointed for this purpose
- By concerned meter readers/ward clerks

ii) In a special round for distribution of bills,

iii) At the time of meter reading for the next round.

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

13.5.4 PAYMENT OF BILLS BY CONSUMER

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

- Counters at various offices of the Board/Corporation/Utility.
- Various branches of bank/banks authorized for accepting payments.
- Door to door/on the spot recovery by concerned person/team.
- Electronic fund transfer through various banks offering such option/directly.
- By cheque through post or drop boxes.
- Through societies authorised by government, such as cooperative societies.
- On line payments.
- Automatic kiosk.

13.5.5 SENDING RECEIPT DETAILS TO BILLING SECTION

The collection counter/bank/person shall send the receipt details to the billing section periodically (preferably daily basis) and the same is entered into the system and the totals cross-checked.

13.5.6 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 can be more efficiently carried out by the computerized system.

13.5.7 FREQUENCY OF BILLING

The frequency of Billing governs the cash flow of the water billing system and thus more frequency means regular cash flow.

The frequency of billing depends mainly on the type of system used. For non-metered system the billing could be quarterly and for the metered system the billing could be bi-monthly. But in both cases all non-domestic, Industrial, Bulk Consumers must be billed monthly. The only other factor which can be considered in this respect is the availability of manpower for billing process and the cost of issuing bills in one complete billing cycle.

13.5.8 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.

13.6 COMPUTERISED WATER BILLING SYSTEM

Computers are now widely used in day to day activities. For a water billing system, which is complex, repetitive and has voluminous data, computerization is recommended. Computerisation overcomes many of the defects in the manual system, is fast and gives a control on the system. Computerisation helps in decision-making. The output formats can be tailored to suit quick retrieval of information that is necessary for decision making. Consultants and experts are now available to help in setting up a computerized system.

13.6.1 ADVANTAGES OF COMPUTERISATION

The advantages of the computerisation of billing and collection are as follows; • Listing of customer accounts with unnerved bills.

- Quantity analysis on line.
- Query for list of debtors.
- Quick MIS for on the spot analysis of important parameters.
- Bills generated for the month.
- Amount collection up to the date.
- Number of connections.
- Total working and Nonworking meters.
- Disconnection.
- Water consumption.
- Demand Collection Balance (DBC) statement.
- Receivables monitoring and fixation of targets for billing.
- Performance indicators.
- Meter reader performance.
- Collection efficiency.
- Billing pattern.
- Water consumption.
- Billed units.
- Reports on debtors requiring continuous persuasion.

CHAPTER - 14

WATER AUDIT & LEAKAGE CONTROL

14.1 INTRODUCTION

WATER AUDIT

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

14.2 OBJECTIVE OF WATER AUDIT

The objective of water audit is to assess the following.

j) Water produced,
k) ii) Water used,
l) iii) Losses both physical and non-physical,
m) iv) To identify and priorities areas which need immediate attention for control.
n)

14.3 PLANNING AND PREPARATION

Planning and preparation shall include the data collection element and the preparation of sketch plans for the distribution centres 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.

14.3.1 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. Refer to 8.4.2.1 and 8.4.2.3 in Chapter on "Operations and Maintenance of Distribution System"

14.3.2 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 supply points.
- All tube wells which supply the system directly.
- Major transfer mains which are expressly required for audit.

At distribution centres, 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:

- Number of properties served.
- Per capita consumption (litres/person/day).
- Population density.
- Hours of supply.

Meter sizes must be sized according to current supply hours. 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.`

14.4 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.

14.4.1 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.

14.4.2 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).

14.4.3 TREATMENT PLANT

The losses in treatment plant can be monitored by measuring the inflow into the plant and outflow 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.

14.4.4 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 utilising 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.

14.5 MONITORING OF DISTRIBUTION SYSTEM

Distribution system comprises of service reservoirs, distribution mains & distribution lines.
Metered, unmetered (flat rate), public stand posts, hydrants, illegal connections
The area of the city is divided into Waste Metering Areas (WMA)/ Sample area zones. Since at one time it is not possible to carry out water audit in all WMAs, it is done for a part of the city at one time followed by other parts of the city in future. This has to be a continuous process managed by a water audit wing or a Leak Detection cell
Water audit of the distribution system consists of:
I) Monitoring of flow of water from the distribution point into the distribution system (WMA).
ii) Consumer sampling.
iii) Estimating metered use by consumers.
iv) Estimating losses in the appurtenances and distribution pipe line network including consumer service lines.

14.5.1 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 flows out into another zone a valve or meter is to be installed at this outlet point.

14.5.2 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• 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

14.5.3 CUSTOMER METERED USE

The average consumption per working meter is calculated by dividing the total consumption of all working meters in the WMA by the number of working meters. This average consumption is then multiplied by the meter correction factor derived from the customer meter sampling exercise in which the serial metering test and bench test of meters is done. Average slow or fast percentage of test recording of meters is known as correction factor. This average metered consumption multiplied by the correction factor is known as water used by consumer.
Unmetered connections & illegal connections will also be treated to have same consumption as metered property.
Estimating customer metered use can also be carried out using the customer data obtained from the customer billing records. Consumption analysis will be carried out by:

• Consumer type.
• Revenue zone/sample area/WMA.
• Direct supply zone/sample area/WMA.
• Overall for the city/Water Supply Scheme.

During the analysis the correction factors derived in the sampling exercise will be applied for metered consumption. Default values will be applied to connections with estimated bill. Public Stand Posts (PSP), unmetered and illegal use will also be treated as metered consumption.

Analysis of the billing data will enable the production of:

- A report on overall water delivered.
- An estimate of water delivered to wards/sample areas/WMA.
- UFW i.e., Physical losses and non-physical losses.
- Errors in assessment of water production. (In case of tube wells).

14.5.4 LOSSES IN CUSTOMER SERVICE LINES AND APPURTENANCES

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

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

14.6 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 into 3 categories viz.

1. Areas that need immediate leak detection and repair.
2. Areas that need levels of losses (UFW) to be closely monitored.
3. 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 it has been established that the components of UFW may generally be as follows:

I) Leakage (physical losses) 75 to 80%
ii) Meter under-registration 10 to 15%
iii) Illegal/unmetered connections 3.5 to 6%
iv) Public use 1.5 to 3.5%

14.7 OBJECTIVE OF 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.

14.8WATER LOSSES

The water losses can be termed into two categories.

1. Physical losses (Technical losses)
2. Non-physical losses (Non-technical losses/Commercial losses)

14.8.1 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.

14.8.2 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.

14.9 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.

14.9.1 PRILIMINARY DATA COLLECTION AND PLANNING

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.

14.10. 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.

14.11 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 suits.

CHAPTER - 15

ENERGY AUDIT & CONSERVATION OF ENERGY

15.1 INTRODUCTION

Energy is very scarce commodity particularly in developing and underdeveloped countries. Cost of energy 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% of overall cost of operation and maintenance of water works. Need for conservation of energy, therefore cannot be over emphasized. All possible steps need to be identified and adopted to conserve energy and reduce energy 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

I) 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.

ii) 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 were installed in all the CWSS executed and maintained by TWAD Board.

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. Hence VFDS were installed in the CWSS executed and maintained by TWAD Board.(where pump sets of capacity more than 20 to 50 HP are available) during the year 2008-2010

15.2. SCOPE OF ENERGY AUDIT

Energy audit includes following actions, steps and processes:

i) Conducting in depth energy audit by systematic process of accounting and reconciliation between the following:

• Actual energy consumption.

• Calculated energy consumption taking into account rated efficiency and power losses in all energy utilising equipment and power transmission system i.e.

ii) 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.

iii) Taking up discharge test at rated head if test at Sr. No. (ii) is not being taken.

iv)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.

v) Identifying solutions and actions necessary to correct the shortcomings and lacunas in (IV) and evaluating cost of the solutions.

vi) Carrying out economical analysis of costs involved in (iv) and (v) above and drawing conclusions whether rectification is economical or otherwise.

vii) Checking whether operating point is near best efficiency point and whether any improvement is possible.

viii) Verification of penalties if any, levied by power supply authorities e.g. penalty for poor power factor, penalty for exceeding contract demand.

ix) 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.

15.2.2 METHODOLOGY FOR ENERGY AUDIT

Different methodologies are followed by different organisations for energy audit. Suggested methodologies for installations having similar and dissimilar pumps are as follows:

15.2.2.1 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.

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

(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 litres 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.]

15.3 ESCO CONCEPT for Energy Audit

Govt. of Tamilnadu ordered to implement a new concept of Energy Servicing Components (ESCOS) for undertaking Energy auditing.

According to this concept these energy servicing 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	Corro – coating of pump impellers	Oct. 02 to Jan. 03	29,32,505`	26,50,300	2,82,205

CHAPTER – 16

LIFE CYCLE COST APPROACH& SERVICE DELIVERY APPROACH

16.1.1 LIFE CYCLE COST APPROACH—

Life cycle cost (LCC)represents the aggregate costs of ensuring delivery adequate, equitable and sustainable 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 , that is capacity building, planning and monitoring at both District and National level, not just for a few years, but indefinitely.
The delivery of sustainable services requires that financial 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 .This is the 'life cycle 'at the heart of this approach –what is needed 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 WASH services, to make reliable cost information readily available and to mainstream the use of LCC in WASH 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 WASH infrastructure to maintain provision of 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 while spending the least.

16.1.2 COST COMPONENT S CONSIDERED IN THE LIFE CYCLE COST APPROACH

Capital expenditure- hardware and software (Cap Ex)-includes the Concrete structures, Pumps, pipes, Filtration units etc.to develop and extend the service.
Operating and minor Maintenance Expenditure (Op Ex)-Requirement for recurrent(regular, ongoing) expenditure on labor, fuel, chemicals, material and purchases of any bulk water(5% to 20 % of capital investments).
Capital maintenance expenditure (Cap Man Ex)-Expenditure on asset renewal, replacement and rehabilitation covers the work that goes beyond routine maintenance to repair and replacement in order to keep system running.
Cost of capital (Co 'C) - Cost of Financing a Program or Project i.e. the cost assessing the funds needed to construct a system.
Expenditure on direct support (ExpDs)-it includes expenditure on both pre-and post-construction support activities.
Expenditure on indirect support (Exp IDS)-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.
Total Expenditure (Tot Ex)-determined using fixed assets accounting to aggregate the cost components described above.

16.2.1SERVICE DELIVERY APPROACH

A service delivery approach is a concept for ensuring the sustainability of rural WASH 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 Water & Sanitation 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 or sanitation facility 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 is an initiative of triple –S (Sustainable service at scale) in collaboration with the WASH cost project. to improve WASH to the rural poor.

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 and construction of infrastructure and the software (capacity building ,institutional support ,financial planning)and maintenance required to sustain a certain level of water and sanitation 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

16.2.2 Why the Service Delivery Approach matters

In the early 1990s, an estimated 30% to40% of rural water supply system in developing countries were 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:

In the developing World ,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 – 17

SYSTEM MANAGEMENT

17.1 INTRODUCTION

17.1.1 NEED FOR EFFECTIVE MANAGEMENT

Lack of effective management or poor management is the single largest factor which causes the greatest negative impact on 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 is to provide to the consumer the best quality service at the lowest cost.

17.2 SYSTEMS APPROACH TO MANAGEMENT

17.2.1 SYSTEMS APPROACH

In a systems 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 commercial, 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.

17.2.2 ADVANTAGES OF SYSTEMS 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 and hence facilitates analysis of the

17.2.3 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.

17.2.4 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 by the agency 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 will be gathered for pointing out potential problems such as 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.

17.3 MANAGEMENT INFORMATION SYSTEM (MIS)

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 centres of decision and each of these is supported by an information system. 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.

17.4 DATABASE OF RURAL WATER SUPPLY SCHEME (ANNEXURE)

To achieve efficient and effective performance of rural water supply scheme following 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 and clean 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 is enclosed as categorized as below

1-A	GENERAL
,2-B-1	Surface Source
3-B-2	under Ground Source
4-c	Rising Main
5-D	Storage
6-E	Pumping Machinery /Power
7-F	Filtration
8-G	-Distribution
9-H	Water Revenue
10-I	Re-Organization / Contingency Works/ Deposit Work
11-J	Water Quality Assurance Monitoring