सत्यमेव जयते

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

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WATER TREATMENT PLANT

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Centre
for
Advanced
Maintenance
TECHnology

उच्च अनुरक्षण प्रौद्योगिकी केन्द्र

Excellence in Maintenance

Maharajpur, GWALIOR - 474 020

Foreword

Water Treatment Plant plays an important role in water supply system network.

Its proper and regular function ensures the provision of safe and adequate potable water to the user. This book draws the focus on the operation and maintenance aspects of water treatment plant. Inspection schedule as laid down in IRWM, routine-abnormal operational and maintenance instructions as described in various codes and books are incorporated as a ready reckoner to the personnel, dealing with water supply system.

I am sure this book would be of considerable help to all Civil Engg. Personnel for improvement in maintenance and handling of water treatment plant.

CAMTECH, Gwalior ***M.L.Gupta***
Date : 31.08.2001 ***Executive Director***

Preface

Potable water is the one of the fundamental requirements of civilisation. Our Engg. department bearing the responsibility of effective arrangement of water supply for all Railway Stations, offices and colonies of Indian Railways.

We are using different kind of resources of water, as per the availability at that nearby place, like river, lakes, borewell etc.. Many places Engg. Department has established their own water treatment plants, to meet the demand of potable drinking water, so the maintenance of water treatment plant and their management has become an important aspect for Engg. department. The main objective of this book to provide a concise and complete knowledge regarding maintenance problems and their remedies, which are coming in day to day operation and maintenance of water treatment plant.

This handbook does not supersede any existing instruction from Railway Board, IRPWM, RDSO etc. except where necessary correction slips intimating the required changes are issued by Railway Board/RDSO.

I am grateful for the assistance given to me by Shri Anupam Sharma, CTA/Civil/CAMTECH, who went through the complete text, collected information, data etc. and done editing work. Nice data entry has been done by Shri Ramesh Bhojwani, CO/CAMTECH.

We welcome any suggestion for improvements from our readers.

CAMTECH, Gwalior ***J.K.Nandanwar***
Date : 31.08.2001 ***Director/Civil***

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ISSUE OF CORRECTION SLIPS

The correction slips to be issued in future for this handbook will be numbered as follows:

CAMTECH/C/2001/WTP/1.0/CS. # XX date .....

Where "XX" is the serial number of the concerned correction slip (starting from 01 onwards).

CORRECTION SLIPS ISSUED

Sr. No. of C.Slip	Date of issue	Page no. and Item No. modified	Remarks

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CHAPTER - 1

GENERAL INSTRUCTIONS

Joint operating, Engineering, Mechanical Engineering and Electrical Engineering Department's Circular No. 92/Ele. (G)/150/12 :

(Authority : Central Rly.'s Circular No. 92/Ele. (G)/150/12)

Procurement, Installation, Operation and Maintenance of pumps for water supply installations :

1. Introduction

1.1 Consequent upon large scale dieselisation electrification, replacement of bulk of steam traction on the one hand & provision of electric pumps substituting the steam and diesel pumps and providing diesel pumps only as a stand by, on the other hand, the need for redefining the responsibilities in respect of procurement, installation, operation and maintenance of pumps has arisen. This joint circular is, therefore, issued in super session of the earlier circular issued on 08.3.1972.

1.2 These instructions will come into force with effect from 01.10.94.

2. Procurement and installation :

2.1 Electric pumps and diesel pumps :

2.1.1 Electrical department shall be responsible for procurement, installation and operation of electrical pumps whether permanent or temporary including those at filtration plants meant for domestic water supply. Stand by diesel pumps should be dispensed with gradually, wherever possible and where stand by is a must, the existing stand by diesel pumps will continue to be maintained by Mechanical department. In case any of these diesel pumps are due for replacement and at the condemning stage these will be replaced by diesel generating sets of minimum required capacity to drive the existing electric pumps. Such stand by sets are to be identified jointly by divisional officers of Electrical and Mechanical branch. The procurement and maintenance of diesel generating sets with associated switch gear will be the responsibility of Electrical department. The existing operating and maintenance staff of Mechanical department should be re-deployed/transferred for use of Electrical department.

2.1.2 At locations where there are no electric pumps and only diesel pumps are provided, these will be installed by Mechanical department. At such

locations, if it's replacement is to be done with electric pump, the entire process of procurement of electric pumps and their process of procurement of electric pumps and their installation will be done by Electrical department. Staff under Mechanical department should be re-deployed for maintenance of electric pumps which have replaced the diesel pumps.

2.2 Water main and control valves :

2.2.1 The responsibility for procurement, installation and laying of water supply distribution system including the controlling valves shall be responsibility of the Civil Engineering department.

The non return valves, in case these are provided alongwith the pumps, electric or diesel shall be procured and installed by the Electrical/Mechanical department along with the pumps. Except foot valve all other control valves and non return valves should be procured and maintained by Engineering department.

2.2.2 Procurement of valves for replacement shall be done by Engineering department which is responsible for maintenance of the system alongwith control valves.

3. Operation

3.1 Electric pumps

3.1.1 Operation of electric pumps/diesel stand by pumps meant for supply of raw water from main source from river or Municipal Corporation, Reservoirs shall be the responsibility of the Electrical Department. Further responsibility of control of electric pumps has been decided by the Board vide Board's letter no. 92/Elec (G)/150/12 dated : 26.8.92, according to which control over such pumps will be as indicated below :

(A) At smaller stations where neither electrical non engineering supervisors are head quartered:- under station master.

(B) At stations, where an engineering supervisor is headquartered, but not electrical supervisor is headquartered:- under Engineering supervisor.

(C) At stations having both engineering and electrical supervisors are headquartered:- existing arrangements to continue.

(D) Repairs and maintenance of electrical equipment for categories (A) and (B) should be arranged locally and Electrical department's help be asked only for major works.

3.1.2 At way side stations, the station master shall be trained to operate the pumps.

3.1.3 At stations where a valveman is posted, he shall be trained to operate the pumps.

3.1.4 At filter house and water treatment plants where special staff is provided for the purpose of water treatment and for filter house, such staff will also operate the electric pumps and stand by diesel pumps connected with the filter/treatment plant. The staff shall be borne on the cadre of Civil Engineering department. Necessary training for operation of these pumps and a certificate to this effect shall be given by the Electrical department. The training of the staff and issue of competency certificate shall be borne at divisional level by Electrical department.

3.2 Diesel pumps

3.2.1 Operation of Diesel pumps : Operation of diesel pumps as well diesel stand by pump for supply of raw water from main source shall be responsibility of Mechanical department.

4. Maintenance

4.1 Electric pumps & stand by diesel pumps

4.1.1 Electrical department shall be responsible for the maintenance and heavy repairs for all electric pumps and stand by diesel pumps meant for domestic purpose.

4.2 Diesel pumps :

At places where only diesel pumps are existing, the maintenance, heavy and running repairs shall be continued to be done by Mechanical department. However, wherever these pumps are replaced with electric pumps and stand by diesel pumps, the maintenance shall be done by Electrical department.

4.3 Pipelines and control :

Maintenance of the pipelines, controlling valves etc. will be the responsibility of the Civil Engineering department. At the pumping installations its responsibility will commence from the delivery valve of the pump. The maintenance of the foot valve on the suction side will be done by the agency maintaining the pumps. However, in large river pumping installations where jack wells are provided with long and heavy suction pipes, the maintenance of the suction pipe lines and foot valve between the pump and the jack well, be the responsibility of the Civil Engineering department.

4.3.1 Maintenance of suction pipe line together with valves at all water pumping points except filtration plants will be the responsibility of the Electrical department who will maintain these along with the electrical installation and stand by diesel pumps. Electrical department shall be responsible only for maintenance and repair of electric equipment i.e. pump, motor, starter etc.

5. General

5.1 The pumping installations and surroundings shall be kept in a decent condition by the pump operators. The pumping staff will also be responsible for cleaning and removing obstruction from the inlet and foot valves. Cleaning of strainers will also be done by operators. The grass weeds, algae and floating debris shall be removed by Engineering department. Desilting of well, duct line porous pipes shall be done by Engineering department. Intermediate setting tank, if any provided should be cleaned by Engineering department.

5.2 As per existing practice the adequacy of availability of water at all stations on each division would be got reviewed by DRM's every year after the monsoon and measures taken by the DRM's to augment supplies and improve quality of water wherever felt necessary to ensure adequate and potable drinking water especially during the summer and monsoon seasons.

Inspection by Divisional Engineer –

The Divisional Engineer should inspect the water works in every detail once a year and record his notes in the Inspection Register maintained for the purpose.

Inspection by Assistant Engineer and staff

a) The Assistant Engineer and Section Engineer (Works) should frequently inspect all water supply installations and pipelines and ensure their maintenance in efficient condition. The Section Engineer (Works) should be equipped with an adequate imprest of materials such as pipes and specials and water taps of requisite sizes and the necessary tools to facilitate immediate attention on repairs as and when required.

b) Storage-tanks for drinking water and for flushing purposes over offices, bungalows and quarters should be inspected frequently by the Section Engineer (Works) and their cleanliness ensured. Complaints from residents should be promptly attended to.

Inspection Register – An Inspection Register should be maintained at each water purification work to enable every inspecting officer of the Engg. and Medical Department to record notes. Prompt action on inspection notes should be ensured.

Water Purification Works

a) Periodical analysis of water – Samples of raw, filtered and sterilised water from filter plants should be sent for examination and certification once a month or as may be prescribed to the Divisional Medical Officer who will advise, if deemed necessary, on the appropriate dosage of the coagulant or the sterilising agent. Reports on water analysis received form the Divisional Medical Officer should be carefully filed, the action taken on each report being recorded. Samples for chemical examination should be sent for testing once in six months or one before monsoon and once after monsoon.

b) Maintenance of water works – Detailed instructions in regard to the maintenance and operation of filtration and chlorination plants at each installation shall be issued by the Chief Engineer. It should be ensured that :

- The plants, in general, with their ancillaries are maintained in a perfectly sanitary and hygienic condition.

- Aeration of raw water is affected by spraying through the air, cascading over obstacles.

- The sedimentation tanks or basins are drained at such intervals as prescribed;

- Coagulants, either in the form of dry powder or in aqueous solution, or added in the correct proportion according to the turbidity of raw water;

- The filters are cleaned and washed with pure water at such intervals as prescribed;

- The filtered water is sterilised either by adding liquid chlorine or bleaching powder strictly to the dosage specified.

- Disinfectants are stored properly and all safety precautions are taken.

- The water works staff incharge shall strictly adhere to the prescribed rules. A copy of the detailed instructions on the operation of plant and purification process should be available at each installation together with the duty lists of the staff posted there.

c) Supervision by Assistant Engineer

The AEN shall inspect each installation once in three months and record his notes in the inspection register maintained for the purpose. He should follow the course of water from the point of intake and through the different treatment stages to the point of delivery to the distribution mains and arrange to remedy defects noticed.

AEN should arrange for a joint detailed inspection by Section Engineer (Works) of the pumping machinery once a year as may be prescribed alongwith the staff of the Mechanical/Electrical Department and ensure prompt compliance to repairs or replacements required.

The Assistant Engineer should check the following:

- Stock account-showing transactions of stores.
- Log book for filtration plant

Water supply plans

Up to date plans should be maintained in the Offices of Chief Engineer's Divisional Engineer, Assistant Engineer and Section Engineer (Works) of every water supply system showing the source, pumps and pumping particulars, rising mains, storage tanks and capacities, the distribution mains, service pipe, hydrants and taps. The diameters and type of pipelines should be clearly indicated on the plans and on the longitudinal sections.

Where there are separate supplies for drinking and other requirements, the respective systems should be shown on the plan in different colours or on separate plans.

The Assistant Engineer shall ensure that water supply plan is corrected as and when there is any addition or modification in pipeline. Wherever the laying/modification to the existing pipeline is done through contractual agency,

a certificate in the measurement book shall be recorded while entering the final measurements to the effect that necessary changes in the plans have been incorporated. In case of Construction Organisation implementing any water supply scheme or augmenting the existing scheme, a copy of the water supply plan shall be handed over to open line as and when the scheme is completed.

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CHAPTER – 2

WATER TREATMENT

Quality of water

It should be ensured that the water supplied is clear, potable, and free from pathogenic organisms and odour. Water should be of reasonable temperature and free from minerals, which could produce undesirable physiological effects.

The physical and chemical standards as per table given below may be adhered for drinking water supply.

STANDARDS OF QUALITY OF DRINKING WATER
Physical and chemical standards

Sr. No.	Characteristics	Requirement (desirable limit)	Permissible limit in the absence of alternate source
1	Turbidity (NTU scale) 5.0	10	
2	Colour Haten units 5.0	25	
3	Taste and odour	Un-objectionable	-
4	pH value	6.5 to 8.5	No relaxation
5	Total dissolved solids (mg/l) max.	500	2000

6	Total hardness as $CaCo_3$ (mg/l) 250	300	600
7	Chlorides as Cl_2 (mg/l) 250	1000	
8	Sulphates as SO_4 (mg/l) max.	200	400
9	Fluorides as F (mg/l) max.	1.0	1.5
10	Nitrates as No_3 (mg/l) max.	45	100
11	Calcium as Ca (mg/l) max.	75	200
12	Iron as Fe (mg/l) max. 0.3	1.0	
13	Zinc as Zn (mg/l) max. 5.0	15.0	
14	Mineral oil (mg/l) max. 0.01	0.03	
15	Copper as Cu (mg/l) max. Toxic materials	0.05	1.5
16	Arsenic as As (mg/l) max.	0.05	No relaxation
17	Cadmium ad Cd (mg/l) max.	0.01	-do-
18	Lead as Pb (mg/l) max. 0.05	-do-	
19	Residual free chlorine (mg/l) max.	0.2*	-

Source: Indian Standards – Drinking water – specification (First revision) IS : 10500-1991 by BIS.
* When protection against viral infection is required, it should be min. 0.5 mg/l.

Bacteriological Guidelines: The recommend guidelines for bacteriological quality are given in Table:

BACTERIOLOGICAL QUALITY OF DRINKING WATER

Organisms	Guideline value
All water intended for drinking.	
E.coli or thermotolerant coliform bacteria (ref. a,c)	Must not be detectable in any 100 ml sample
Treated water entering the distribution system	
E.coli or thermotolerant coliform bacteria (ref. b)	Must not be detectable in any 100 ml sample
Total coliform bacteria	Must not be detectable in any 100 ml sample
Treated water in the distribution system	
E.coli or thermotolerant coliform bacteria (ref. b)	Must not be detectable in any 100 ml sample
Total coliform bacteria	Must not be detectable in any 100 ml sample. In case of large supplies, where sufficient samples are examined must not be present in 95% of samples taken throughout any 12-month period.

Source: WHO guidelines for Drinking Water Quality Vol. 1 – 1993

a) Immediate investigative action must be taken if either E.coli or total coliform bacteria are detected. The minimum action in the case of total coliform bacteria is repeat sampling these bacteria are detected in the repeat sample, the cause must be determined by immediate further investigation.

b) Although E.coli is the more precise indicator of faecal pollution, the count of thermotolerant coliform bacteria is an acceptable alternative. If necessary, proper confirmatory test must be carried out. Total coliform bacteria are not acceptable indicators of the sanitary quality of rural water supplies, particularly in tropical areas where many bacteria of no sanitary significance occur in almost all untreated supplies.

c) It is recognises that, in the great majority of rural water supplies in developing countries, faecal contamination is widespread. Under these conditions, the national surveillance agency should set medium term targets for progressive improvement of water supplies, as recommended in volume 3 of WHO guidelines for drinking water quality 1993.

Water Samples for Analysis

Whenever the quality of water from any source or from taps is to be tested and samples are required to be collected by the Engineering Staff, the following procedure should be followed :

a) Sterilised glass-stoppered bottles available with the Divisional Medical Officer should be obtained. Bottles separately available for bacteriological or chemical examination have to be appropriately used.

   The paper cover of the stopper should be removed just before taking the samples. The stopper should be removed just before filling the bottle and replaced immediately after. The stopper should be held from the top while the bottle is being filled. Contamination while filling the bottle must be avoided. There should be no external contact with the mouth of the bottle or the part of the stopper that goes into it. The bottle should be filled to about 25 mm below its neck.

b) When samples of water are taken from a tap, the mouth of the tap should be heated by a spirit lamp for 3 minutes. Water should then be allowed to flow for 5 minutes before the sampling bottle is filled.

c) If the sample is to be obtained from a tank or a reservoir or a river, the unopened bottle is to be held in water about 300 mm below the surface and away from the edge without disturbing the bed. The stopper should

then be removed, the bottle withdrawn when full, a few drops of water poured out and the stopper replaced and tied down.

d) Well water should be collected by lowering the bottle (tied with a piece of weight) into the well by a string attached to the neck the stopper should be removed by another string tied to it and the bottle filled in with water, not from the surface but from a point a metre or two above the bottom of the well. If collected from a tube-well with a pump, the water should be allowed to flow for about 20 minutes.

e) Bottles containing samples of water should be properly labelled, packed around with ice and saw-dust and sent without any delay to reach the Divisional Medical Officer. Satisfactory packing and expeditious dispatch are essential for proper bacteriological examination.

Method of Treatment

The aim of water treatment is to produce and maintain water that is hygienically safe, clean and potable in an economical manner. Treatment should ensure the desired quality at the end points of consumption.

The method of treatment to be employed depends on the nature of raw water and the desired standards of water quality. The unit operations in water treatment constitute aeration, flocculation (rapid and slow) and clarification, filtration, disinfection, softening, deferrization,

defluoridation and water conditioning. Different combinations are possible to achieve the required quality of water. The choice of any particular sequence of treatment will depend not only on the quality of the raw water available but also on the comparative economics of alternative treatment steps to get desired quality.

In case of ground water storage which are well protected, where the water has turbidity below 10 NTU and water is free from odour and colour, plain disinfection by chlorination is adopted before supply.

Where ground water contains excessive iron, dissolved carbon dioxide and odorous gases, aeration followed by flocculation and sedimentation, rapid gravity or pressure filtration and disinfection may be necessary.

Conventional treatment including pre-chlorination, aeration, flocculation and sedimentation, rapid gravity filtration and post chlorination are adopted for highly polluted surface waters laden with algae or other micro organisms.

Water with excessive hardness will need softening by conventional method or by ion exchange method.

Disinfection of water

Water treatment processes described in paragraph above remove micro-organism to varying degrees. For utmost safety of water for drinking purposes, disinfection of water

has to be done to remove disease-producing organisms before it enters distribution system. Disinfection is also required to prevent contamination of water during its transit from the treatment plant to the place of its consumption. The efficiency of disinfection depends on the nature of disinfectants. For treatment on larger scale, chlorination is generally used as treatment for disinfection. Chlorine can be applied in water by using bleaching powder, chloramines or as free chlorine gas. A minimum of 30 to 60 minutes contact time must be provided before delivery of water to the consumer.

Sufficient number of chlorinators in working conditions should be available with the Inspector of Works. To decide the quantity of chlorine to be added, Inspector of works should find out breakpoint chlorination and accordingly chlorinate the supply.

Disinfection through chlorine

Disinfection is an important unit operation in a water treatment practice. This process is brought about by addition of chlorine either in the form of gas or bleaching powder to the water body. In a water treatment plant, this chlorination is effected n two stages (i) prechlorination (ii) post chlorination. Prechlorination is done to reduce the algal population, which may otherwise hinder the process of coagulation and filtration.

Post chlorination is recommended on the filtered water to make it suitable for human consumption.

Chlorine acts as a disinfectant by the :

a) Destruction of micro-organisms
b) Oxidation of Fe, Mn, H_2S
c) Removal of taste and odour producing compounds
d) Oxidation of organic compounds by producing chloro-derivatives.

For effective chlorination in water treatment practice it is necessary to ascertain (a) dose of chlorine required (b) optimum contact period and (c) the presence of residual chlorine (.3 to .5 mg/l). from experience it has been found that a contact period of 30 minutes is adequate to disinfect water.

When chlorine is added to water, very quick hydrolysis takes place as follows :

$Cl_2 + H_2O$ - HOCl + HCl

Hypochlorous acid is very unstable and HOCl ionises to

HOCl - $H^+ + OCl^-$

The equilibrium in Cl_2, HOCL, OCl^- is dependent on pH of water and HOCl, OCl^- forms are known as free residual available chlorine. At pH around 2 - Cl_2 ; 2.5 – 7 pH HOCl; and at pH 8.5 and above entirely OCl^- exists.

Beyond a certain stage, any added chlorine, remains in the form of free **residual chlorine**. This point is known as **break point**. At his point all pollutants are destroyed and free residual chlorine starts forming.

The existence of residual chlorine in treated water, therefore, provided indication of the water being free from any organic impurities and also safe from aquatic and bacteriological contamination.

Chlorine demand

Chlorine and chlorine compounds by virtue of their oxidising powder can be consumed by a variety of inorganic and organic materials present in water before any disinfection is achieved. It is, therefore, essential to provide sufficient time and dose of chlorine to satisfy the various chemical reactions and leave some amount of unreacted chlorine as residual either in the form of free or combined chlorine adequate for killing the pathogenic organisms.

The difference between the amount of chlorine added to water and the amount of residual chlorine after a specified contact period is defined as the **chlorine demand.** The chlorine demand of any given water varies with the amount of chlorine applied, the time of the contact, pH, temperature, and type and quality of residual desired.

Estimation of chlorine

The usual tests practised for estimating the residual chlorine in water are the orthotoulidine test **(OT**) and orthotoulidine arsenite test **(OTA),** the former used for total residual chlorine concentration and the latter for free available chlorine. When orthotoulidine reagent is added to water containing chlorine; a greenish yellow colour develops, the intensity of, which is proportional to the amount of residual chlorine present. Soluble tablets of DPD (diethylphenylene-diamine) have also been used satisfactorily in place of orthotoulidine reagent.

Residual Chlorine

General

The residual chlorine is estimated to assess whether the water is satisfied to its chlorine demand or not. The existence of residual chlorine indicates that the water is safe from reducing and organic substances and also that the harmful aquatic and bacteriological masses have been properly disinfected. Min. residual chlorine available at the farthest end shall be 0.2 mg/l. During monsoon months or if specific complaints are there, super-chlorination more than 2 PPM of chlorine may be resorted to effectively get rid of bacteria.

Principle

Orthotolidine method is recommended as the most easiest and applicable method for the estimation of residual chlorine Orthotolidine produces yellow coloured compound with

residual chlorine, the intensity of the colour can be compared with the standards prepared.

Interference

This method measures total residual chlorine (free and combined). The test is subject to interference by production of false colours for chlorine when Nitrite, Iron or Manganese is present in the water. It may be applied, however, when the ferric iron content and the Nitrite-Nitrogen content are both under 0.2 ppm, and when not more than 0.01 ppm of manganic-Manganese is present.

Apparatus

Nessler tubes – 100 ml. colour comparator

Reagents

Orthotolidine reagent: Dissolve 1.35 gms. Orthotolidine dihydrochloride in 500 ml. distilled water. Add this solution, with constant stirring, to a mixture of 350 ml. distilled water and 150 ml. of concentrated HCl. The reagent should be stored in amber bottles or in the dark-protected from direct sunlight, and used no longer than 6 months.

Permanent chlorine standards

a) Phosphate buffer stock solution 0.5 M : Dry anhydrous Na_2HPO_4) overnight at 110^0C and store in a desicator. Dissolve 22.86 gms of this Na_2HPO_4 together with 46.16 gms. of KH_2PO_4 , in one litre of distilled water. Allow time for any precipitate to form. Filter before using.

b) Phosphate –buffer solution – 0.1 M : This is a standard buffer, pH 6.45. Filter stock solution as prepared above and dilute 200 ml. to 1000 ml. with distilled water.

c) Strong Chromate – Dichromate solution : Dissolve 1.55 gms. $K_2Cr_2O_7$, and 4.6 gms. K_2CrO_4 in 0.1 M phosphate buffer.

d) Dilute chromate – Dichromate solution : Dissolve 0.155 gms. $K_2Cr_2O_7$ and 4.65 K_2CrO4 in 0.1 M phosphate buffer and dilute to 1 litre with 0.1 M phosphate – buffer.

e) Permanent chlorine standards (0.01 to 1 mg/l. concentration): Place the quantities of dilute chromate – dichromate solution indicated below in 100 ml. Nesslers tubes and make upto the mark with 0.1 M phosphate buffer solution.

CHLORINE STANDARDS

(0.01 to 1.0 mg./l)

Chlorine Mg./l	Chromate – dichromate solution (ml.)	Chlorine Mg./l	Chromate – dichromate solution (ml.)
0.01	1	0.3	30
0.02	2	0.35	35
0.05	5	0.45	4
0.07	7	0.6	60
0.1	10	0.7	70
0.15	15	0.8	80
0.20	20	0.9	90
0.25	25	1.0	100

Procedure

Use 0.5 ml. orthotoulidine reagent for 10 ml. sample, 5 ml. for 100 ml. sample and the same ration for higher volumes. Place orthotoulidine reagent in the Nessler tube or other container, add sample to the proper mark or volume, mix rapidly, and allow standing for 5 minutes. Compare the colour developed, against the standards.

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CHAPTER – 3

OPERATION & MAINTENANCE OF WATER TREATMENT PLANT

Requirements

Maintenance should be carried out in a manner, which prevents emergencies and unscheduled shutdowns. An efficient maintenance requires considerable skill, which can only be acquired experience, study and practice. Basically, any maintenance programme should observe the following general rules:

a) Keep a set of plans giving details of the several units and indicating the layout and position of all pipelines and appurtenances;

b) Establish a systematic plan of daily operations;

c) Establish a routine schedule for inspection of machinery and lubrication and maintain records thereof. Instructions for lubrication, the type of lubricant suggested and the frequency of lubrication should be drawn;

d) Main data and record of each piece of equipment giving details of cleaning and faulty operating conditions. Details for any special equipment should be obtained from the manufacturers;

e) Keep a record of analysis of water collected at various points from the source to the distribution system and observation on the effect of such quality on the several units of operation ; and

f) List out safety measures including good housekeeping.

General Maintenance

The backbone of the successful plants is the regular preventive maintenance by the operating staff. The following are the general points to be noted for the maintenance. Besides, the instructions are outlined for important operative equipment in the manufacturer's instruction manuals.

Oil levels are to be checked and the deficit level is to be made up by using the recommended grade of oil.

Reduction gears.

Oil lubricated pumps (if any).

The frequency of application and type of lubricant to be used is to be followed as per the manufacturer's instruction manual.

The major greasing points to be checked once in a week are listed below:

- Plumber Blocks
- MS shutter sides
- Handwheel operated spindles/valves.

- The sprocket and chain drive for Clarifier.
- Clarifier central bearing.
- Motors

Recommended grade of grease:

- Shell Retiflux – A
- Mobilax – 3
- Multipurpose grease – 3

Some hand-operated shutters, which are not in regular use, should be operated from time to time for easy movement and prevention of failure when required to be put into service.

The carbon brushes of the current collector box should be checked for abrasion and wear every three months and replaced when worn out, with brushes suitable for use in slip ring (5 rings) induction motor.

'V' belt drives, couplings should be checked for tension and alignment and adjusts periodically, if necessary.

The common problems encountered in water treatment plants are:

Raw Water

The problem will mainly relate to the change in the quality of the raw water due to natural causes and by adverting pollution of the source.

In the case of river source, a sanitary survey of the catchment area should be undertaken at regular intervals and water samples taken at significant points where pollution is likely to take place. The analysis of these samples will reveal the degree and nature of pollution and thus help in taking the necessary measures to check or control the pollution. If the fluctuations in quality are rapid, the surveys should be undertaken at shorter intervals. Turbidity is not a special problem as the dosage of the coagulant is adjusted on a daily routine. On the other hand a sudden rise in chlorides content will indicate pollution most probably due to sewage. In such cases, more confirmatory test should be undertaken such as for nitrogen in its various forms, dissolved oxygen absorbed and chlorine demand to help the operator whether pollution has taken place and to fix the dose of prechlorination needed.

In the case of a lake as a source the periodical biological and physical examination of the samples will indicate if there is any need for control of algae which may lead to taste and odour problems or clogging of filters. Samples taken at different depths in the lake will indicate the level at which water should be drawn to get the best quality of water.

1) Flow Measuring Devices

Float sump should be periodically cleaned so see that silt does not accumulate which may affect the proper functioning of the float. Charts and pen recorders should be stocked adequately. Annual or more frequent calibration of these devices is necessary. Annual servicing and checking of the instruments is imperative.

2) Chemical feeding unit

Alum preparation tank is to be painted annually by anti corrosive paint. V-notch weirs and floats and floating arrangements should be cleaned daily. Enough spares for the mixing device in the chemical preparation should be stocked. Setting of the V-notch should be checked periodically.

Sometimes, if the alum dosing equipment is not in order, the alum slabs are just dumped in the raw water channel. This is bad practice and should not be adopted as it will mean wastage of alum and improve dosing of alum. Alum should be made into a solution and dispensed until the dosing equipment is rectified. The optimum dosing of alum and coagulant aids should be based on a proper and detailed laboratory study including Jar Test. The chemical feeding rate should be controlled, depending upon the needs from time to time.

3) Rapid Mixer

Adequate spares should be kept ready in stock for timely replacement when necessary. Periodical painting with anticorrosive paints could prolong life of the equipment.

4) Slow Mixer

Slow Mixer should be operated continuously for avoiding sludge built-up. All equipment should be painted with anti-corrosive paints every year. Mechanical devices should be properly lubricated and worn out parts replaced. In non-

mechanical type of flocculators like baffle and tangential flow tanks. Desludging atleast once in six months is necessary.

5) Aerators

Aerators are required to be maintained in a clean condition so that maximum water surface and agitation are provided.

Slime and algae growth on the surface would require cleaning and periodic treatment with copper sulphate with or without lime to kill growth. The porous or tubes used with diffusion aerators may become partly clogged either from dust in the compressed air or from the collection of sediment on the outside surfaces. When Aerators are shutdown, appropriate cleaning with detergents or acid brush should be attempted. Clogging of diffuser plates could be minimised by

i. maintaining air filters in effective operation
ii. not over-lubricating air compressors and blowers
iii. maintaining air pressure on diffusers when compressors are shut down.

6) Clarifier or Sedimentation Tank

Annual overhauling and repainting of the unit should be done a month or two prior to monsoon.

Sludge lines should be kept free of chokages. The lines should be flushed with high-pressure water if chokages are noticed. The telescopic sludge discharge device, when provided, should

be checked for free vertical movement and O-rings replaced when leaky.

The traction wheels should be checked for alignment and rubber wheels replaced, if required.

The unit should be worked continuously to protect the mechanical parts from ill effects of corrosion, malfunctioning etc., as well as problems from sludge built-up. Outlet weirs should be kept cleaned at all times. Algaecide or bleaching powder may be used for controlling biological growth or weirs.

i) Important features in the operation of Clarifier are:

a) The introduction of water into the tank with a minimum turbulence;

b) The prevention of short circuiting between inlet and outlet; and

c) The removal of the effluent with the minimum of disturbance to avoid settled material being carried out of the tank.

Very often, a basin which is not functioning properly can be modified by making changes to the inlet and outlet devices by installing stilling baffles so as to improve any or all of the important features mentioned above. **Algal growth**, if any should be controlled.

ii) Algal growth

During summer season, reasonably higher quantities of algal species are reported in the river water. Stagnant water is also liable to have algal growth. The intensity of algal growth depends upon the type of algal species, the prevailing nutrient conditions and other physio-chemical characteristics of water. The major species of trouble causing algae can be identified with aid microscope. Algae impart colour, odour and anaesthetic taste to the water body. Adequate pre-chlorination effectively curbs the algal nuisance. Besides chlorination, application of copper sulphate and potassium permanganate have also been found to be effective. Before conducting the chemical treatment for algal destruction, it is necessary to ascertain 'chlorine demand' and oxygen absorbed at 37^0 for 4 hours, of the water for the optimum implementation of the chemical dosage without affecting the performance of the proceeding treatment units. The pre-chlorinated water should not contain residual chlorine since excess of residual chlorine partially retards the efficiency of the chemical treatment during coagulation process.

7) Rapid Gravity Filters

a) Deflection gauge: Rate of flow gauges and loss of head gauges frequently get out of order. The operator should be conversant with the working of gauges and should be able to handle minor repairs. Necessary spares should be stocked.

However, even if the rate of filtration gauge is under repairs, the filtration rate can be checked whenever desired by closing the inlet valve and observing the time during which the level of water in the filter falls by measured distance.

For knowing the loss of head when the gauges are out of operation, a temporary arrangement consisting of two glass tubes on each side of a calibrated scale could be provided. One tube is to be connected to the effluent pipe between filter and controller and the other tube to the filter structure above the sand. The relative elevation of the water surfaces in these tubes indicates the prevailing hydraulic gradient or loss of head through the filter.

b) Slime growth: When slime growths are noticed on filters, the bed is cleared in the normal way and the water is lowered to the level of the sand bed. Then common salt is distributed evenly over the surface of the sand, using 7kg/m^2 of filter area, after which the wash water valve is opened until water rises above 15 cm above the sand level. The water is allowed to remain for 2 hours to dissolve the salt and then lowered to the bed level to be retained for 24 hours after which it is thoroughly back washed before placing into service. If this procedure does not produce effective results, it may be necessary to replace the media.

c) Backwash requirements: The waste water drains carrying filter back wash water is led away quickly,

there will be no backing up in water channel or into the filter bed. Incidentally, it may be worthwhile to consider setting up a plain sedimentation tank to recover the supernatant from the backwash water. For the small investment, the water recovery could be appreciable.

The requisite upflow velocity of backwash water should be maintained at the design rate for proper cleaning of the sand. The practice of backwash at reduced rate for longer periods should be avoided as it leads to wastage of water and washing becoming ineffective.

Backwashing of filters should not be based on arbitrarily fixed time schedules but the frequency should be in accordance with the filtrate quality and head loss measurement. Duration should be dependent upon the turbidity of the wastewater.

d) Mud ball formation of filter beds:

With deficient washing gelatinous material on the sand grains are not washed off. They accumulate and agglomerate to form 'Mud Balls' in the initial stages, after back washing, the mud balls being lighter are deposited on the media and are seen easily. Unchecked formation of mud balls will eventually result in large balls sinking through the agitated sand during the washing process and then collecting between gravel and sand this will cause clogging of gravel which will:

a) Reducing efficiency of filter beds.

b) Uneven distribution of wash water and thereby sand in free area.

c) Formation of jets during washing which dislodges the gravel and the gradation of filter media is no longer level.

By proper coagulation and settling of applied water, mud-ball formation could be considerably reduced. Surface wash, or surface raking, or shovelling at intervals helps reduce mud ball formation. Also compressed air scouring during backwash for periods of three minutes, instead of 1 to 2 minutes, effectively decreases mud-ball concentration.

e) Crack in sand beds:

The existence of cracks in sand under water indicates that the sand grains are being cemented together by some material in the applied water. Organic matter, fine clay, oil and the very gelatinous floc formed at times when micro-organisms are coagulated or developed in the beds have been found to cement the sand grains and this causes shrinkage of sand bed. This causes cracks and is most likely to occur at the filter walls and the sand is drawn away from the walls.

The gelatinous film on the sand grain may be removed by treatment with alkali or chlorine.

a) Wash the bed thoroughly as possible and have water above the sand upto slightly lower level than the trough.

b) Dissolve 5-10 kgs. of caustic soda in this water for each square meter of filter area.

c) Filter until the water level reduces almost upto 1" above the same.

d) Allow to act for 6-12 hours.

e) Wash the bed thoroughly.

Similar procedure may be followed for the treatment with chlorine also but use 0.2 kg. of calcium hypochlorite per sq. m. filter area and let the solution act for 12-24 hours, before washing.

If algae infested water is applied on sand, alkali/chlorine treatment as enumerated above clogs the media.

f) Air binding in filter beds:

Air binding is caused due to the accumulation of air in the filter bed and under drains. The trouble occurs during the winter season when the dissolved air content of the water is at maximum or due to operation of filter under 'negative head'.

Shutting off the filter for a few minutes to eliminate the negative head or washing the filter for 1 or 2 minutes would remedy the situation by releasing the retained air in the system. Air binding would materially reduce the rate of filtration or impair the filtrate gravity.

g) Bumping of filter beds:

Sometimes careless and indifferent operation may lead to 'bumping' or 'lifting' of the filter beds when switching on the back-wash for a minutes to dislodge the sand bed and recommencing filtration without going through the full backwash cycle is adopted. This practice should be discouraged as the filtrate quality deteriorates considerably.

h) Inadequate media on the filter bed:

Expansion of sand bed during Backwashing should be kept within the limits to avoid carry over the sand to wash water through which would lead to appreciable depletion of sand depth over a period of time. Sand depth should never be depleted by more than 10 cm. after which the media has to be replenished. The entire bed should be taken out and additional sand mixed to give the required effective size and uniformity coefficient. Before starting the filter, the sand has to be backwashed to stratify the bed.

i) Defective Gauges:

Rate of flow gauges and loss of head gauges frequently get out of order. The operator should be conversant with the working of the gauges and should be able to handle minor repairs. Necessary spares should be stocked.

However, even if the rate of filtration gauge is under repair, the filtration rate can be checked whenever desired by closing the inlet valve and observing the time during which the level of water in the filter falls by a measured distance.

For knowing the loss of head when the gauges are out of operation, a stop gap arrangement consisting of two glass tubes on each side of calibrated scale could be provided. One tube is to be connected to the effluent pipe between filter and rate controller and the other elevation of the water surfaces in these tubes indicates the prevailing hydraulic gradient or loss of head through the filter.

8) Problems related to the quality & flow pattern:

When flow gets reduced, it may be desirable to cutout certain units but it is preferable to operate all the units with reduced flow conditions. In any case, the flow through condition in the several units should be periodically studied using appropriate tracers. This will help to locate if there is any short-circuiting so that corrective measure can be adopted.

The flow condition in open channels should be examined periodically to avoid obstructions and heading up which will affect the unit process especially the efficiency of the clarification unit.

9) Sludge carry over from clariflocculator:

Sometimes it is observed that the chemical flocs are carried over alongwith the clariflocculator effluent. This may happen due to heavy accumulation of sludge in the clariflocculator resulted from improper desludging. Periodic and proper sludge withdrawal is recommended as a remedy.

During lean periods, when the turbidity of raw water is very low, the phenomenon of sludge carry over in clariflocculator has been observed. In such cases addition of weighting agents like Fuller's earth, calcite etc. or re-circulation of settled sludge solve the problem.

Excessive addition of chemicals used for coagulation or else imbalance addition of chemical also tends to add to the sludge carry over in clariflocculator. To avoid this performance of Jar Test dosing of chemical accordingly has to be done for the proper functioning of the plant.

10) Master balancing reservoirs and elevated reservoirs

Important aspects to be considered during maintenance are :

i. Measurement of inflows and outflows : Whenever measuring devices are provided, it should be seen that discharge at inlets fairly tallies. It should be seen that water level indicators and recorders are in proper working order.

ii. Structural Leakage: A structural damages and leakage should be promptly repaired.

iii. Preventing External Pollution: The manhole opening ventilating shafts and overflow pipes should be properly closed and protected with wire gauge from external pollution.

iv. General cleanliness in the around the reservoir should be maintained and observed. A garden around the reservoir structure may be provided.

v. A programme for periodical cleaning of the reservoirs atleast once in a year should be undertaken. During such cleaning process there should be facility to bye pass the supply to distribution system.

vi. Appropriate safety measures to prevent climbing of unauthorised persons should be provided. All the railings provided shall be maintained in a safe and firm condition.

Start up Preparation

- Check and ensure that the pump sets, motors valves, piping etc. are secured and in proper alignment.
- Remove all construction materials and tools lying in and around units.
- Ensure that the drainage is in working condition.
- Fill up the bearings, gearboxes and the moving parts with the correct grade and quantity of lubricants.
- Turn unit by hand to ensure free movement of pump and drive shafts.
- Ensure that the power supply is sufficient to run all the equipment at full load.
- Ensure that the correct grades of chemical are available in ready stock at least for one month.

Shut down

The following procedure is recommended to be adopted when the plant needs to have a shut down.

a) Out of raw water supply and additional of chemicals to the respective points.

b) Withdraw the settled sludge completely from the clariflocculator and then stop the bridge and flocculating paddles.

c) If the shut down is planned for 24 hours, the mixing arrangements in chemical preparation tanks should be kept on the entire period. On the increase of the duration of shut down, these may be kept stopped and should be restarted atleast six hours before the start up of the plant for achieving a homogeneous solution slurry.

d) Backwash the filter beds as procedure mentioned in filters operation and keep it ready for restart.

e) Agitators in flash mixer are to be stopped.

f) All pumps are to be stopped.

Safety

General

In the operation of any plant safety of personnel and equipment is an important consideration. Precautionary measures for personnel working near rotating machinery or at a higher elevation etc., are common for any plant and hence, they are not elaborated here. Handling of chemicals only needs special mention.

i) Hydrated Lime

Lime is supplied as a very fine powder of the order of 100-mesh size. Handling this chemical hence gives dust nuisance. Use safety goggles, gas mask, gloves, apron and boots.

ii) Alum

Alum is commonly available in the form of blocks, which needs to be made into pieces for quick dissolution. Because of Hygroscopic characteristics, alum and its solution cause irritation on skin. Rubber aprons, gloves, boots and safety goggles are recommended for use while handling the alum.

iii) Chlorine

Chlorine vapour is extremely hazardous to human health. On leakage, avoid prolonged or repeated breathing inside the chlorinator room. Suitable gas mask may be used while handling chlorinator unit.

iv) Coagulants

Handling

1. Ordinarily a plant labourer can handle 50-kg container when aided by small handcart. Heavy container should be handled with the aid of mechanical contrivance such as trucks, monorails, cranes and other special equipment.

2. Rolling of cylinders, barrels, drums on the floor should be avoided.

3. Iron salts generally require more careful handling as compared to alum salts.

4. While laying electrical wiring and fixtures adequate safety precautions should be observed during their installation for ensuring safe use of electricity.

5. Use of mechanical lifting devices should be preferred.

Storage

1. The coagulant store should be suitably located to prevent entry of water. Where coagulants are purchased in bags, storage by piling on the floor of the storeroom shall be suitably located at a convenient level.

2. In case when coagulants are purchased in blocks, the height of stack is generally limited up to 3 m for non-operational stacks and 1.5 m for operational stacks.

3. Coagulants should be stored in a damp-proof storage room.

4. Hygroscopic coagulant should be packed in moisture-proof container.

5. All plants, particularly small ones should keep on hand at all times the supply of coagulants sufficient to provide a safety factor. A storage of 3 months based on average consumption is advisable. Special consideration should be given to requirements of the monsoon season. But this again depends upon the type and form of coagulant, location of the plant, source of supply, transport facilities and the arrangement made with the suppliers.

6. In case where the major storage is provided at a place away from the feeding device a week's storage space should be provided near the coagulants feeding device to facilitate handling. Special precautions against flooding should be taken.

7. The floor of the storage room should be given anti-corrosive treatment. Similar treatment should also be given to side walls and intervening columns, upto a minimum height of 3 m above the floor level.

8. A working space of minimum 30 % of floor area should be provided so that all stacked coagulants are easily accessible.

Weighing

1. It is necessary that predetermined quantity of coagulants is used for preparing the solutions. Arrangements of weighing of coagulants both when the consignments are received as well as before feeding it into the equipment should be provided.

2. Depending upon the quality of the coagulant, appropriate weighing machine conforming to IS may be used.

Solution tanks

Number of tanks

There should be three dosing tanks. For avoiding the interruption in dosing, one of them would be for preparation, other for dosing and the third as a stand by (for being got ready for receiving coagulants after cleaning). However, when the coagulant solution is to be used at the rate of 5000 litres per 24 hours or less, the number of solution tanks can be restricted to 2, each tank to hold solution for 24 hours. When the quantity of coagulants used is large, more than one tank may be used to meet 8 hours dose.

Level Indicators

Level indicators shall be installed in the solution tanks to know the quantity remaining in the tank at any given instant. The level indicator should be such that they are not affected by the agitation of liquid in the tank.

Preparation of coagulant solution

Mixing Devices

It is essential to ensure homogeneity of the prepared coagulants solution. Proper mixing may be done by the following methods.

Mechanical Agitation

The normal turnover capacity of the agitators for the alum solution tank should be 2 hours.

Compressed Air

Agitation by compressed air is particularly economical for large size tanks and also when number of tanks is more than four.

Air supply should be 0.1 to 0.15 m^3/minute per m^3 of effective liquid capacity of solution tank. The pressure of air supply will depend upon depth of liquid and losses through distribution pipe and orifice holes. High density polyethylene, unplasticized PVC or polypropylene pipe

should be used as distribution pipe inside the tank at a level 300 to 350 mm above tank bottom.

Air agitation need not be continuous. Five minutes agitation followed by 20 to 30 minutes of rest is sufficient to keep the solution homogeneous.

Re-circulating solution

When re-circulation pumps are provided the capacity should be sufficient to turn over the tanks content in 2 hours.

Water for preparing Coagulants

Whenever filters are installed filtered water should be used for making chemical solutions. In absence of filters or in industrial water treatment plant settled clear water may be used.

v) Chlorination equipment and container room

Installation

1) Chlorine gas units and cylinders shall be housed in separate rooms, easily accessible, close to the point of application and convenient for truck loading and safe container handling. The floor shall be flat and at least 150 mm above the surrounding ground and drainage shall be adequate. The height of the container room should be at least 4.0 m. under no circumstances such

units shall be housed in basement or below ground level since the chlorine gas is heavy and settles into depressions.

2) The exits shall lead directly out in the open and the doors shall open outward. The hinges of the doors should be parliamentary types. At least two exits shall be provided in each such room.

3) Adequate arrangements for air circulation and cross ventilation shall be made in the rooms. Air entry shall be from above and air exit shall be from below. Exhaust fans shall be provided at floor level.

4) Rooms for chlorine containers in which more than 200 kg chlorine is stored shall be separated from the chlorine gas apparatus rooms and shall be accessible only from outside.

5) Containers shall rest securely on cradles or on a level rack equipped with adequate safety block to prevent rolling and be slightly elevated from the floor to keep them dry.

6) The temperature in the installation room shall be within the range of +4 to $+40^0$C. The chlorine gas containers and chlorine gas pipes shall not be exposed to direct heat radiation and shall be protected from sunrays.

7) Electrical installations inside the chlorine gas rooms shall be limited to the absolute minimum required.

While laying electrical wiring and fixtures adequate safety precautions shall be observed during their installation of ensuring safe use of electricity. Note: Rigid PVC conduits should be preferred.

8) The following information shall be indicated prominently on the outside entry door:
"Chlorine gas dosing apparatus room"
"Smoking and handling naked flame prohibited".
"Admission restricted".

Handling

1) Ordinarily a plant labourer can handle up to 100 kg. cylinder when aided by small handcart. Heavy containers shall be handled with the aid of mechanical contrivance, such as trucks, monorails, cranes or other such equipment.

2) Chlorine gas container shall not be bumped, dropped or rolled on the ground and no object shall be allowed to strike them with force.

3) Use of mechanical lifting devices is recommended. For lifting one tonne container, the capacity of the mechanical device should be about 2 tonnes.

Storage

1) All plants, particularly small ones, should keep on hand at all times sufficient supply of chlorine cylinders or drums.

2) Special consideration shall be given to requirements of monsoon seasons.

3) Cylinder shall confirm to IS: 7681-1975 and the provisions of IS:8198 (Part 6)-1979 for filling inspection, testing, maintenance and use of containers for storage and transportation of liquefied chlorine in cylinders shall be observed.

4) Cylinders shall be stored vertically so that a leaking container, if found, can be removed with the least possible handling of others. Tonne containers shall be stored on the sides all the time horizontally with suitable rollers or saddles.

5) Tonne containers are equipped with two valves each with an internal eduction pipe. A removable hood is provided to protect the valves from injury during shipment and handling. In placing tonne containers in position for use, the two valves shall be in vertical alignment. The eduction pipes then permit the upper valve to discharge gas and the lower valve liquid chlorine.

6) No other objects except chlorine gas storing containers shall be kept in the room.

Safety

1) All operating and storing rooms for chlorine gas appliances and containers shall be fire proof.

2) Chlorine storage rooms should preferably be provided with chlorine gas alarm device which gives out an acoustic or an optical signal when the chlorine gas concentration is reached, the set value for which is 1.0 mg chlorine per cubic metre of air in case of a person working in the room and 20 mg chlorine per cubic metre of air when no human being is inside the room.

3) The sensor for alarm device shall be placed not higher than 300 mm above the floors of the room.

4) A bottle of ammonia is essential to detect leaks, etc., in case alarm device is not provided.

5) Cylinder as well as chlorine shall be tested at every shift period for leaks, first by trying to detect the sharp irritating smell of chlorine, then by passing over each cylinder and around each valve and pipe connections, a rod with a small cotton-wool swab tied on the end, dipped in an aqueous solution of ammonia. If chlorine is present in the air, the swab will appear to smoke due to formation of white cloud of ammonium chlorine. If the leak appears to be heavy, all persons not directly

concerned should leave the area and the operator should put on his mask and make a thorough search of the leak.

Note: In tracing a leak, always work down-stream that is start at the cylinder and work down along the line of flow until the leak is found.

a) Safety equipment, like gas masks, rubber gloves, aprons shall be housed in easily accessible (unlocked) cupboard placed outside the chlorination room.

Note: Faulty gas mask is worse than none at all. Hence these shall be tested frequently and canisters shall be changed at proper intervals.

b) First aid box and eye wash fountain shall be provided outside chlorinator room.

c) The provisions shall be made for emergency disposal of chlorine from leaking containers. The proportions of alkali and water recommended for this purpose are given in Table 1.

Table – 1

Container capacity Kg.	Caustic soda		Soda ash		Hydrated lime	
	100% Kg.	Water L	100% Kg.	Water L	100% Kg.	Water L
45	57	180	136	450	57	570
67	85	275	204	680	85	850
1000	115	3640	2272	9090	115	1150
Note: When chlorine is to be absorbed in hydrated lime, the solution should be continuously and vigorously agitated.						

d) Water shall never be applied to the chlorine leak to stop it, as it will only make it worse.

e) When a chlorine leak occurs, the ventilation system should be operated immediately before any person enters the chlorination room.

Note: Ventilation system should be controlled from outside.

f) The exhaust pipe of the apparatus shall lead to the open through the shortest path and the outlet of this exhaust pipe shall not be readily accessible.

g) In case of fire, the cylinders and drums containing chlorine shall be protected by spraying with water since the containers can burst at temperatures of over 70^0C. Source of pressurised water shall be provided adjacent to the chlorination room.

h) Before disconnecting the flexible leads from containers to gas headers, the cylinder valves should be closed first and then the gas under pressure should be drawn from the header and flexible leads before the header valve is closed.

i) Solvents, such as petroleum, hydrocarbons or alcohol should not be used for cleaning parts, which come in contact with chlorine. The safe solvents are chloroform or carbon tetrachloride. Grease should never be used where it comes in contact with chlorine.

j) No direct flame should be applied to the chlorine cylinder when heating becomes necessary.

k) The protective hood over the valve should always be kept in place except when the cylinders are in use.

l) In addition to this, the relevant provisions of IS : 4263-1967* shall also be observed as far as applicable.

General House Keeping

Good house keeping for any treatment plant is mandatory for obtaining a satisfactory performance. It calls for the establishment of systematic approach. A single individual should be responsible for conducting various activities and co-ordinating effectively the various functions. Promptness in decision-making and enforcing the same form a vital factor in better house keeping.

CHAPTER - 4

SLOW SAND FILTERS

Operation and Maintenance

1) Slow sand filters should be operated continuously 24 hours of the day, as intermittent operation will impair filtered water quality. In case there is any interruption in raw water flow, the filters should not be shut down, but allowed to filter at a declining rate.

2) Generally, all the filter beds of a plant should be kept operating and no bed should be kept idle, as standby and idle units will take several days after they are started to reach full efficiency.

3) Filter bed should be cleaned one at a time. When one bed is being cleaned, other beds may be overloaded to maintain total plant output. Overloading for short period will not affect filtration efficiency.

4) Cleaning of a filter bed should be completed as quickly as possible and the bed re-commissioned within 18 hours of initial shutdown to limit the adverse effect on the biological flora in the filter.

5) The inlet float valve should be periodically checked with a view to maintain the desired level in the bed.

6) The outlet weir arrangement should be checked periodically with a view to ensure the design rate filtration. Where there is telescopic arrangement, it should be functioning smoothly and without drawing in water through the sides. Where manual adjustment is to be done with increasing filter heads, this should be done at specified intervals.

7) The filter head indicator should always be kept in working condition. When a filter is clogged, most of the head loss is restricted to the top layer of sand and if the filter head exceeds 1 m, pressure below atmospheric can occur in sand gravel and in the under drains leading to air binding or dissolved air coming out of solution. Occurrence of negative head can be avoided by placing the sill of the outlet weir in level with the top of the sand bed.

8) It is most important to avoid rapid fluctuations in filtering rates. Cleaned or resanded filters should be brought up gradually to the maximum filtering rate and maintained as far as possible at a constant rate until the head reaches the maximum of 1 m when the bed should be taken up for cleaning.

9) On no account the filter bed be allowed to get reduced by disturbing the top of the sand, as this will impair the bacterial efficiency of the filter.

Resanding

When the sand level in a filter has been reduced to the minimum permissible level of 0.5 to 0.6 m, the filter bed should be resanded. In resanding the throwing over method should be followed.

1) Filters, which have been drained down below the sand level, should first be back-filled with filtered water from adjacent filters before top filling with raw water. New filters should be back-filled with as clean water as possible before top filling.

2) New filters and resanded filters should be run to waste until the bacteriological quality is satisfactory which may take several days.

3) When filtering to waste is not feasible, special care should be taken to chlorinate the filtrate before supply.

Throwing over the carried out in strips Excavation is carried out on each strip in turn, making sure that it is not dug as to disturb the gravel layers below. The removed materials from 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 resanded, the material in the ridge from the first trench is used to cover the new sand in the last strip.

Chlorinators

The chlorine demand of filtered water is to be satisfied and a free chlorine residual maintained to make it completely safe. Hence the operator should be careful in administering calculated doses accurately.

Bubbling the chlorine gas through the filtered water stored in the clear water reservoir by dipping rubber tubes connected to chlorine cylinder must be avoided. Chlorine application should be done through a chlorinator only. The chlorinator should be maintained properly. If the unit is out of order, the same should be repaired quickly and re-commissioned.

A complete understanding of the principles of operation of chlorine gas feeders and familiarity with tests for pinpointing leakage are essential. Low capacity units require frequent cleaning of the rotameter and rate setter. Large capacity chlorinators must have vaporisers. The gas piping and feeders should be completely dismantled every one or two years to clean out accumulated impurities.

Clear Water Sump & Reservoir

Roofing should be periodically checked to ensure that no leakage are there so that pollution can be prevented. Ventilator outlets should be checked and cleaned to guard against breeding and bird dropping. Cleaning of the sump and reservoir should be done regularly. Level recorder should be kept in working order at all times.

The total capacity of clear water reservoir should be adequate for storage of treated water especially during low supply periods at night when reservoir become full. Instances are reported, where water from the filters has backed up into inspecting galleries, thus reducing the rate of filtration. The remedy lies in having additional clear water reservoir in the plant, or arrangement for the final water to be automatically pumped to the balancing.

Treated Water

The quality of water distribution may be controlled by adjusting the calcium carbonate balance in the water to safeguard against corrosion or excessive scale formation in pipes. The periodical analysis of the water can also indicate if there is any biological growth in the main and if any further chlorination is needed to check it. The samples of water collected from several points should be routinely examined for residual chlorine and other chemical and bacteriological parameters.

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CHAPTER - 5

PUMPS

Types and selection of Pumps

a) The types of pumps in general use are reciprocating, centrifugal, airlift and vertical spindle deep well turbine pumps. Hydraulic rams are useful and economical in perennial streams for supply of comparatively small quantities of water.

b) Reciprocating pumps have nearly a uniform efficiency over a large range and therefore greater flexibility in operation. Reciprocating pumps may duplex, triplex or quadruplex accordingly to the number of water-cylinders and are suitable for pumping from open wells. They are. However, not suitable for tubewell operation as the intermittent suction has a damaging effect on the strainers.

c) Centrifugal pumps are efficient, economical and require little attention. The suction lift is, however, limited as in the case of reciprocating pumps.

   In tube-wells where centrifugal pumps cannot be installed sufficiently close to the water table, airlift pumps may be used. Their efficiency is, however, low and should not normally be used for capacities in excess of 35000 litres per hour.

d) Vertical spindle deep well turbine pumps are suitable for tube wells of large size they are easy to operate and have a high efficiency. They should be used in tube wells, which are free from grit and where competent supervisory staffs are available, as adjustments during repairs require skilled attention.

   Submersible pump is suitable for comparatively smaller installations. It consists of an electric motor and pump both submerged in water; the vertical spinning shaft is dispensed with, the water being pumped through a vertical pipe.

e) Pumping units should be so selected that they could be operated continuously at rated load, as the units are operated most efficiently at the rated load.

f) Pumping capacity should not exceed the yield of the source, so as not to damage the strata through which water filtrates into the source.

Pump Installation

While installing a pump, the following points should be paid attention :

a) The foundation should be sufficiently strong to absorb vibrations and to form a permanent, rigid support for the base plate. The foundations shall be designed for the loads as per IS:2974 Part IV – 1979.

b) The suction lift, which should be made as low as possible; the greatest suction-lift that may be expected at sea level is about 7 metres.

c) The suction pipe should be airtight laid with as few bends as possible and equipped with foot-valve.

d) Near the pump, a non-return (reflux) valve and a delivery valve (sluice or butterfly valve) should be provided. The non-return valve should be between the pump and the delivery valve. The size of the valve should match the size of pipe.

e) The delivery pipe shall be of such size that the velocity of water is about 2.5 m/s.

f) A dismantling joint must be provided between the pump and the valves. The design of the dismantling joint should be such that no pull or push is transmitted to the pump.

g) Sufficient space for generating sets should be available in the pump house to locate the pump, motor, valves, pipes, control panels in a rational manner with easy access and with sufficient space around for the maintenance and repairs. The minimum space between two adjoining pumps or motors should be 0.6 m for a small or medium unit and 1.0 m for large units.

   Space for control panels should be planned as per the Indian Electricity Rules.

Driving Units

The driving unit may be an electric motor or an oil engine. Where power is available:

a) The prime mover should preferably be an electric motor, being economical;

b) The stand-by where provided may be an electric generator so that in case of failure of electric supply, pumping is assured.

c) Where power is not available, oil engines may be used.

d) Non-return valve at the discharge pipe, supplemented by the sluice valve shall not be closed while the pump is running.

Capacity of Pumping

The pumping system should be capable of supplying:

a) In 12 hours or less, the normal quantity required in 24 hours;

b) In 16 hours or less, the present maximum quantity required in 24 hours.

c) In about 20 hours, the estimated maximum future requirements in 24 hours.

For small pumping systems, generally of capacity less than 15 million litres per day, two pumps (one duty and one standby of full capacity) should be provided. Alternatively, two duties and one standby, each of 50% capacity may be provided. Although this alternative would need larger space, it facilitates flexibility in regulating the water supply. Also in an emergency of two pumps going out of order simultaneously, the third helps to maintain at least partial supply.

In the case of medium and large pumping stations, at least two standbys should be provided. Electrical department is responsible for installation and maintenance of electrical machinery/equipment.

Pump Horse Power

P.H.P. = L (H+h)/4560

Where P.H.P. is the pump horsepower (metric): (One metric horsepower = 75 kilogram metres/Sec.), H is the vertical height in metres from suction-level to highest point of discharge; L is the litres of water per minutes and 'h' the head lost in friction in metres.

8% extra for incrustation in the case of cast iron pipes may be allowed while calculating PHP. The relation between the pump horse power and the indicated horse power or brake horse power of the engine working the pump depends on the type of engine and type of pump and their efficiency.

Trouble Shooting

The anticipated troubles, their possible causes and remedies are tabulated below for the ready reference. Nevertheless, if any of the trouble does not respond to the remedies, it is suggested to refer the matter immediately to the concerned personnel.

Sr. No.	Symptom	Possible Cause	Remedy
1	Pump fails to start.	a) Priming not proper.	Check suction valve & level in suction tank. Valve should be open and suction head adequate.
		b) Clogged impeller.	Shut down the pump start stand by pump inform Foreman
		c) Incorrect direction of rotation (This may be due to wrong wiring)	

2	Delivery is below the designed capacity.	a) Air leaking into suction line or stuffing. b) Clogged impeller. c) Incorrect direction of rotation. d) Low voltage e) Worm wearing ring/damaged shaft sleeve/ defective stuffing box/damaged gasket.	Shut down pump start standby inform Foreman. -do- -do- -do- -do-
3	Pump works for a while and then stops.	a) Poor priming. b) Air pocket in suction and delivery line.	Check suction piping and valve.
4	Rapid wearing of coupling.	Misalignment	Inform Foreman

5	Heating of bearings	a) Misalignment b) Improper lubrication.	Inform Foreman
6	Motor runs hot.	a) Misalignment b) Low voltage c) Overload d) Defective motor	Shutdown & inform Foreman and start standby.
7	Pump Noise	a) Clogged foot valve or strainer b) Foreign body in the impeller. c) Loose or damaged impeller d) Misalignment e) Insecure foundation f) Worn bearings.	-do-

8	Stuffing box leaks	a) Improper locations of seal cage in the stuffing box. b) Misalignment c) Improper packing d) Dirt in the sealing liquid.	Inform Foreman, start standby pump.
9	Packing wears out faster	a) Leaking stuffing box. b) Worn bearings c) Tight gland	Inform Foreman, start standby pump
10	Pump fails suddenly.	Power failure.	Close discharge valve. When power is restored repeat the start up procedure.

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CHAPTER - 6

PIPE LINES

Conveyance of water from Source.

a) Gravity conduits should be accurately set out to the necessary gradient and covered to prevent contamination; they should be provided at the lowest point with a scour sluice and with manholes not farther apart than 250 metres and at all beds and changes of gradient.

b) For pressure mains, galvanised screwed pipes upto 80 mm diameter may be used; for diameters over 80 mm, cast iron spigot and socket or reinforced concrete or suitable asbestos pipes should be used as per relevant BIS specification.

c) Cast iron pipes – First and second class cast iron pipes in stock when used should be treated with a suitable solution in order to reduce corrosion and encrustation.

Pipe laying and Fitting of Valves and Meters

a) The following instructions should be followed :

1) For a gravity line, the pipeline may follow the contour of the ground so long as frequent and abrupt changes in gradient are avoided, and it is well below the hydraulic gradient under conditions of maximum discharge.

2) Keep the top of pipe at least 0.5 metres below ground surface and where severe frost occurs, the cover is at least 1 metre. The bed of the trench shall be finished to an even gradient/level and filled with soil rammed in 150-mm layers.

3) Provide air valves at all summits and scour valves at all sags.

4) Lay spigot and socket pipes with sockets facing the direction from which the water will flow.

5) Carry pipes across deep depressions or marshy places on pillars or props.

6) On steep hillsides, anchor the pipe to prevent sliding of pipes down slope in vertical position, use pipes with flanged ends and bolts as far as possible.

7) Close the open end of the last pipe at the end of the day's work.

8) Test the pipeline with water pressure in sections before the trench is filled in.

Pipelines should be fitted, where necessary with :

a) Air valves of proper size and pressure rating at summits.

b) Reflex (non-return) valves at the foot of all ascending parts of the main.

c) Scour valves at depressions on the main for clearing sediment and emptying the pipes.

d) Sluices as necessary in order to divide the main into convenient section for repairs.

e) A ball cock at the discharge end of a gravitational main when the discharge into a tank or reservoir is to be automatically controlled. A ball cock must only be used at the end of a pumping main if there is a safety or relief valve on the main.

f) Meters as required.

g) The covers and glands of all valves should be removed, packing adjusted, spindles and gates examined and the whole assembly refitted in free and perfect order before installation.
In tube-wells where centrifugal pumps cannot be installed sufficiently close to the water table, airlift pumps may be used. Their efficiency is, however, low and should not normally be used for capacities in excess of 35000 litres per hour.

h) Vertical spindle deep well turbine pumps are suitable for tube wells of large size they are easy to operate and have a high efficiency. They should be used in tube wells, which are free from grit and where competent supervisory staffs are available, as adjustments during repairs require skilled attention.

Submersible pump is suitable for comparatively smaller installations. It consists of an electric motor and pump both submerged in water; the vertical spinning shaft is dispensed with, the water being pumped through a vertical pipe.

i) Pumping units should be so selected that they could be operated continuously at rated load, as the units are operated most efficiently at the rated load.

j) Pumping capacity should not exceed the yield of the source, so as not to damage the strata through which water filtrates into the source.

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OUR OBJECTIVE

To upgrade Maintenance Technologies and Methodologies and achieve improvement in productivity and performance of all Railway assets and manpower which inter-alia would cover Reliability, Availability, and Utilisation.

If you have any suggestion & any specific comments, please write to us :

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