

**GUIDELINES FOR
OPERATION & MAINTENANCE OF
EFFLUENT TREATMENT PLANTS**



Maharashtra Pollution Control Board

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FOREWORD

Proper operation and maintenance of waste water treatment plants is critically important in securing compliance of standards. Successful operation of effluent treatment plants also depend on proper selection of contractor. It is seen that many effluent treatment plants are not producing desired results due to inadequacies in proper operating systems in place as well as lack of technical capabilities of the operator.

The State Pollution Control Board has certain stake in proper operation and maintenance of the effluent treatment plants. Also, there is need to evolve guidelines/criteria for proper operation and maintenance of the effluent treatment plant as well as criteria for selection of its operator(s) in terms of their technical capabilities and experience in the relevant area.

Guidelines for operation and maintenance of waste water treatment plants has been prepared by MPCB in collaboration with Yashwantrao Chavan Academy of Development Administration, Pune. We propose to stipulate these guidelines through consent mechanism to all major industries as well as municipalities having their sewage treatment plants. Comments and useful criticism for improvement would be highly appreciated.

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O & M Related ETP Components

The components of ETP that need O & M are :

- ❖ HT Receiving / LT Sub-station including Transformer
- ❖ Coarse Bar Screens
- ❖ Equalization basins / Raw Effluent Sump (Wet Well)
- ❖ Raw Effluent Pumping Station (Dry Well)
- ❖ Raw Effluent Pumps and Motors
- ❖ Fine Screens
- ❖ Grit Removing Channel
- ❖ Grit Removing Mechanism
- ❖ Flow Distribution Chamber
- ❖ Primary Settling Tank including sludge scrapers
- ❖ Primary Sludge Sump (Wet Well)
- ❖ Primary Sludge Pumping Station (Dry Well)
- ❖ Primary Sludge Pump (s)
- ❖ Anaerobic Sludge Digester (s)
- ❖ Aerobic Treatment Processes
 - Trickling Filter (s)
 - Rotating Biological Discs/ Oxidation Ditch(es) / Carrousal(s)
 - Aerated Lagoons using Mechanical Aerators (Floating / Fixed)
 - Aeration Tanks using Mechanical Aerators (Floating/Fixed) or Diffused Air
- ❖ Secondary Settling Tank (s)
- ❖ Secondary Sludge Sump (s) (Wet Well)
- ❖ Secondary Sludge Pumping Station (Dry Well)
- ❖ Secondary Sludge Handling Pumps
- ❖ Sludge Thickener (s)
- ❖ Sludge Drying Beds
- ❖ Plant Laboratory for testing of Environmental Parameters of pollution
- ❖ Treated Effluent Channel to the outfall stream

O & M Requirement Identification

An ETP installation needs to equip itself with proper protocol for O & M. The first step in preparation for O & M is preparing inventory of maintenance requirements. This inventory is generally included in the Operation & Maintenance (O&M) Manual written down for the installation by the contractor who designs and builds the installation. He on completion of the work hands over this manual to the Principal for whom he builds the installation.

The following sections of the O & M Manual would lay down the maintenance requirements:

1. Maintenance of Equipment: This section provides schedules that list periodic maintenance requirements for the various equipments and also includes record-keeping forms as necessary. A list of equipment suppliers and service representatives along with telephones is also given therein. Also, the manufacturer's O&M requirement is provided in this section. The ETP maintenance staff / the Operation & Maintenance contractor should particularly review this section of the O&M Manual.

2. Storeroom and Spare Parts Inventory: It includes a list of critical replacement parts that may have long delivery times associated with them. Contact details of manufacturers or dealers of various equipment used in the installation, who are located nearby is helpful in seeking recommendations/ guidance. This section also indicates where the spares are to be stored. To optimise spare parts inventory, the ETP Staff/O&M Contractor can make/ procure computerized maintenance software programs to help keep track of spares, supplies and lubricants.

3. Manufacturer's O&M Literature. In the O & M manual, cut-sheets and other manufacturer's literature are also contained.

ETP staff/ O & M Contractor should familiarize itself with all these documents to ensure proper planning and execution of O & M activities.

In case these documents are not available the same should be prepared based on study of the plant, process, equipments, past experience, and interaction with manufacturers/suppliers.

ETP O & M Staff Requirements

The manpower requirement for ETP O & M can broadly be listed as follows:

Plant Manager: is an individual with environmental engineering or science background with experience of at least three years on similar plant(s). He must have thorough understanding of unit operations and application of microbiology and environmental chemistry in the effluent/ sewage treatment. He should be able to take decisions to divert / bypass/ distribute the flow in the event of disruptions / breakdown of mechanical or electrical equipment until resumption is in place and repairs / replacements are successfully carried out. He should understand and be able to plan a forecast and use of chemicals / nutrients for the plant operations and the laboratory. He should be well versed in working out dosages of chemicals and nutrients based on the raw effluent quality and change it as the treatment progresses and results start forthcoming. AS ETP Manager, he should prepare a weekly roster of duties for each individual and broadly lay down in writing the duties and responsibilities of each category of staff. He should ensure that the staff on plant should get rotated in various shifts during each month. Needless to mention that he is the backbone of ETP operation.

Plant Operator(s): comprise a team of qualified / trained operators who work in shifts in operating and maintaining screens, grit removal devices, pumps, aerators, valves, etc. in directing the effluent and settled sludge to various units for / after treatment. They should be able to sense troubles and act as ears and eyes of the Plant manager. They should also assist the electrical / mechanical maintenance technician(s) in carrying out the preventive and breakdown maintenance tasks.

Electrical / Mechanical Technician (s): form team of qualified maintenance technicians with the ability and experience of diagnosing health of equipment and motors with the aim of taking these on for preventive maintenance, assigning causes and reasons for faults and ultimate failure, quickly carrying out minor repairs / replacements by reaching, removing, stripping / opening, repairing, assembling of routine electrical and mechanical machines / equipment including piping and valves.

Laboratory Analyst: is a qualified individual who has knowledge of water and waste water chemistry and is trained in preparation of laboratory chemicals, use of laboratory instruments, collection and preservation of water / waste water samples and analysis for various environmental parameters such as pH, SS, BOD, COD, TDS etc.

Labour / Helpers: In addition to the above trades, labour / helpers are required to assist the above individuals and upkeep and maintenance of the various units, structures, areas, floors, rooms, equipment, tanks, vessels, beds etc. and removal, loading, haulage/carriage of wastes, screenings, stores and chemicals and other such material as the need be.

It is essential that each ETP staff shall be well trained in related tasks and be equipped in resources such as tools, spares and tackles.

ETP O & M skills are acquired mostly through on-job training. Trainees usually start as attendants or operators-in-training and learn their skills on the job under the direction of an experienced operator. They learn by observing and doing routine tasks such as recording meter readings, taking samples of liquid waste and sludge, and performing simple maintenance and repair work on pumps, electric motors, valves, and other plant equipment. ETP Operators need mechanical aptitude and should have knowledge of basic mathematics, chemistry, and biology. They must have the ability to apply data to formulas prescribing treatment requirements, flow levels, and concentration levels.

ETP operation is a team work. It requires proper team selection, training need assessment, training, on-job moulding, laboratory and statistical analysis for ensuring desired performance, trouble forecasting and trouble shooting. O & M staff profile should address all these requirements.

Since it is not feasible to position a Repair/Maintenance Shop at the site to carry out major overhauls / repairs to electrical and mechanical equipment, it is essential to identify back-up workshop facilities. A good ETP operating contractor may have his own central resources in place within workable co-ordinates which will help to carry out such heavy repairs and maintenance or he may have agreement to move such resources, own or from trade, to the site with matching capability to establish temporarily for completion of task. This should be taken in to account if ETP operation is to be outsourced.

ETP Staff Competency

1. Plant Manager:

- a) A Post -graduate in Environmental Sciences or a Graduate Environmental Engineer / Chemical Engineer with one year experience or a Diploma in Environmental / Chemical Engineering/ Graduate in Environmental Sciences /Microbiology with three years experience in an in Maintenance or Design of ETP
- b) Should be physically fit and mentally alert.
- c) Should accept tasks allotted by higher offices and complete these without any further guidance as also have own initiative to find, assign and supervise tasks to his own subordinates to achieve goals assigned to him by the organization.
- d) Should have worked / trained on the operation of a Sewage / Effluent Treatment Plant for at least one year.
- e) Should have attended and participated in a training /refresher course in Effluent Treatment Design/Operation.

2. Plant Operator (s):

- a) Should be at least a High School Pass with sciences and be physically fit and mentally alert.
- b) Should have attended and passed an ITI trade.
- c) Should accept assigned tasks willingly and complete these without any further guidance as also have initiative to find work and willingly undertake it on his own for the betterment / achievement of organizational goals.
- d) Should have attended training / refresher course for personnel working on a Effluent Treatment Plant operation.
- e) Should have at-least one year experience in the operation of Pumps and Valves at a Pumping Installation.

- f) Or should have been a helper for five years and helped Electrical / Mechanical maintenance teams for at least three years.

3. Electrical / Mechanical Technician (s):

- a) Should be at least an SSC Pass with Sciences and be physically fit and mentally alert.
- b) Should accept assigned tasks willingly and complete these without any further guidance as also have initiative to find work and willingly undertake it on his own for the achievement of organizational goals.
- c) Should have attended and passed an ITI in the electrical / mechanical fitter trade.
- d) Should have attended a training / refresher cadre for personnel working on Effluent Treatment Plant.
- e) Should have at least one year experience in the operation as well as maintenance of Pumps, Motors, Switch gears, Reduction Gears, Valves and Pipes at a Effluent Treatment Plant or at a Water Supply Installation.
- f) Or should have been a Plant operator for five years and helped Electrical / Mechanical maintenance teams for at least three years.

4. Labour /Helper:

- a) Should at least be Class VII pass and be physically fit and mentally alert.
- b) Should accept assigned tasks willingly and complete these without supervision and further guidance.

5. Laboratory Analyst:

- a) Should be at least B.Sc. with Chemistry with three years analytical experience or M.Sc. with Chemistry with one year analytical experience.
- b) Should have attended a training / refresher cadre for Laboratory Analysts for working on Effluent Treatment Plant laboratory.

- c) Should be able to draw an Analysis Program for collection and analysis of daily, weekly and monthly samples and follow it and report results as per time schedule thus agreed upon.
- d) Draw out a program to undertake performance studies from time to time and have it approved from the higher offices through his plant manager before execution.
- e) Be responsive and prepared to undertake additional responsibility of the Plant Manager when the incumbent is away for short durations.
- f) Be bold to report deficiencies in treatment as shown by effluent quality analysed at the Laboratory.

ETP Staff Training

“Training Need Identification, Imparting Training, Training Effectiveness Evaluation, and Re-Training” is the Mantra for ensuring reliable ETP operation. This is more so due to high turn-over of ETP staff.

Training can be imparted at ETP site by academic/research institutions, by in-house experts, or by sending staff to courses offered by professional bodies. However, experience shows that the best option is training by experienced ETP operating agency. Such training will be rich in the terms of practical hints, case-studies, and participants will find it easier to communicate with the faculty.

Training courses may be run for 6 to 10 working days at a stretch with residential facilities for batches of 10 – 12 individuals at a time. Shorter courses may be arranged for senior engineers from industry/municipal bodies.

The emphasis in training should be on the following aspects:

1. The Course should commence with a quick visit to the Effluent Treatment Plant where the participants are made conversant with the units / processes that shall be dealt with subsequently in the course syllabus.
2. Introduction of,
 - a) Various unit operations and processes (Separation by Screening, Floation, Settling / Sedimentation, Filtration, Neutralization, Coagulation, Flocculation, Absorption, Adsorption, Chemical Reactions, Oxidation/Reduction, Dissolution, Ion exchange, Chlorination)
 - b) Operation of Units such as Screens (Coarse / Fine Bar screens, Manual / Mechanically operated), Sumps and Pumping Stations including Pumps, Motors and Panels (Centrifugal Horizontal / Vertical Turbine), Valves (Sluice gates, Non return, Reflux), Pipes/Specials and Pipe Joints, Grit Removal Units. Primary Sedimentation / Settling tanks, Scraping Mechanisms, Sludge withdrawal, Sludge Sumps, Sludge Pumps, Aeration tanks and Aerators, Secondary Settling Tanks, Secondary Sludge Sumps, Pumps, Sludge Thickeners, Sludge Digesters, Gas Production, Sludge handling and Drying.

- c) Maintenance of Pumps and Motors, Electrical Panels (Starters, Meters (Energy, Voltage, Amperage, Power factor), Manual or Electrically Operated Trolley Gantry, Blow out Fuses, Valves, Gates, Scraping Bridge Trolley, Aerators, Reduction Gears, Open Air Weather Casings for Motors, Sprocket wheels and Chains for Mechanical Grit and Screen removing devices.
 - d) Introduction to Quality aspects of Raw and Treated Effluent and the importance of each of the quality parameters and corresponding unit operation / process that plays a part in influencing quality parameters.
3. Identification of flaws and troubles with treatment and its trouble shooting where it is not due to inbuilt flaws in design / design criteria, such as bulking of sludge in the lower layers and floating of sludge lumps in a settling tank, foul smelling in an Aeration Tank, heading up in the Settling Tanks or Aeration tanks, passing of undue flocs in the settled effluent from settling tanks, disruption of operation by failure of main power supply and malfunctioning of scraping mechanism in the clarifiers.
 4. Undertaking segregation of a motor and pump from the manifold at suction and delivery, its disconnection from the panel, hauling up of both pump and motor to the maintenance platform, disassembling of the pump, replacement of shaft / impeller, reassembly of the pump, check motor for its characteristics, haul back to the mounting location, couple up / connect the pump and motor and reconnect power and rejoin with suction and delivery manifold.
 5. Undertaking replacement of a mechanical surface aerator in an Aeration Tank and undertake replacement of a Reduction Gear Assembly including its maintenance.
 6. Removing and Replacing of a Sluice Gate Valve from a mains and undertaking maintenance of the Sluice Gate Valve.
 7. Maintaining a Power Factor, methodology and upkeep of the Power Factor Battery Bank.
 8. The role of each of the category of tradesmen on site in bringing the final effluent quality better than the discharge standards.

A separate laboratory training course should be run for only Laboratory Analysts for a period of 6 Working days. It may include:

- a) Introduction to items at Serials 1 & 2 above.
- b) Importance of quality and plant performance parameters e.g. pH, TS, SS, TDS, BOD, COD, DO, Temperature, MLSS, MLVSS and SVI including methods of determination.
- c) A three day regular analysis program in which the participants in pairs are given a sample of effluent for analysis for pH, TS, SS, TDS, BOD, COD, DO, Temperature and a sample of Aeration Tank discharge for determination of MLSS, MLVSS and SVI. The results should be discussed and candidates should be encouraged to express their views as to how these can further be improved.
- d) Preparing sampling schedule (locations, numbers, frequency, grab/continuous), sample preservation methods, statistical tools

Daily training must be followed by a Quiz Test for all cadres before the close of the day and the participants be evaluated based on the outcome of the course results. The participants be presented "Participation Certificates" at the end of the course. This serves as an excellent incentive.

Guidelines for Safety In ETP Operation

Hazard Identification

Effluent treatment plant operators work both indoors and outdoors and are exposed to noise from machinery and to unpleasant odours. Operators' work is physically demanding and work is often performed in unclean locations. Moreover, plants operate 24 hours a day, 7 days a week; therefore, operators work one of three 8-hour shifts, including weekends and holidays, on a rotational basis. Operators may be required to work overtime.

Also, ETP operators are exposed to a variety of hazardous chemical agents, contained in the effluents and to the reagents used in the waste water processing, or generated during the waste waters treatment. These chemical agents may cause acute poisoning, chemical accidents (e.g., skin burns, injury to the eyes, etc.) damage to the respiratory system, allergies, dermatitis, chronic diseases, etc.

Occupational safety and health (OSH) considerations are becoming integral part of modern day operations. In view of this it is necessary to identify hazards and devise preventive and remedial measures to mitigate OSH risks in ETP operation.

The hazards in ETP O & M are listed below:

1. Slips and falls on floors made slippery by water, aqueous solutions or solvents.
2. Blows and contusions caused by falling heavy articles, including containers of chemical reagents, e.g., from overhead conveyers, or by contact with moving machinery or vehicles.
3. Falls into ponds, pits, clarifiers or tanks causing injuries or drowning.
4. Hazards related to entry into confined spaces - suffocation due to oxygen deficiency, poisoning (e.g. by hydrogen sulphide), etc.
5. Burns, by steam or hot vapours, by splashes of hot plating baths, solvents and other liquids, by contact with hot surfaces (e.g., annealing ovens), etc.
6. Electric shock caused by contact with faulty electrical equipment, cables, etc.
7. Cuts and pricks by sharp tools sharp edges of articles to be plated sharp deposits on jigs, etc.

8. Injuries (especially of eyes) caused by flying particles, in particular from rotating brush cleaning or wheel grinding.
9. Fire and explosions due to the formation and release of flammable gases during processing (e.g., methane, hydrogen).
10. Vigorous chemical reactions caused by uncontrolled mixing of chemicals (e.g., if water is mixed with concentrated sulphuric acid) during the preparation of reagents for wastewater treatment.
11. Acute poisoning caused by various chemicals present in the wastes, used as reagents (e.g., gaseous chlorine), or released during the treatment; a particular hazard is caused by the possible release of a number of poisonous gases, e.g., hydrogen-cyanide (from metal plating or heat treatment wastes upon acidification), hydrogen-sulphide, etc.
12. Acute intoxication caused by erroneous drinking of untreated wastewater.
13. Poisoning by phosgene, which may be formed if a worker smokes in the presence of chlorinated-solvent vapours, or if welding or other flames or arcs are used.
14. Chemical burns by corrosive liquids Damage to eyes by splashes of irritating or corrosive liquids.
15. Diseases caused by infectious agents (bacteria, viruses, protozoa, helminthes and fungi – see appendix) present in the raw domestic wastewater (mainly from human origin) and in agricultural wastes.

Dos and Don'ts in ETP Operation for Safety

1. Use safety shoes or boots with non-slip soles.
2. Wear personal protective equipment and chemical resistant clothing to avoid exposure of skin or eyes to corrosive and/or polluted solids, liquids, gases or vapours.
3. Do NOT mix chemicals without the supervision of a qualified chemist or safety professional.
4. Obey all safety-instructions regarding the storage, transport, handling or pouring of chemicals.

5. Check electrical equipment for safety before use; verify that all electric cables are properly insulated; take faulty or suspect electrical equipment to a qualified electricity technician for testing and repair.
6. Wear safety goggles in all cases where the eyes may be exposed to dust, flying particles, or splashes of harmful liquids.
7. Wear respirator, or gas mask, when exposed to harmful aerosols, dusts, vapours or gases.
8. Take extreme care when handling highly corrosive agents such as liquid or gaseous chlorine, concentrated acids or alkalis, or when toxic gases may be emitted from the reagents, etc.
9. Obey all safety instructions concerning entry into confined spaces, e.g., check atmosphere for oxygen or for poisonous gases, use respiratory protection equipment if needed, have a co-worker stand guard in case of need for help, etc.
10. Do not smoke, eat or drink in areas where chemical or biological contamination may be expected.
11. Use non-latex gloves if sensitivity to latex has been diagnosed.
12. All workers should undergo periodic examinations by occupational physician to reveal early symptoms of possible chronic effects or allergies.
13. Learn and use safe lifting and moving techniques for heavy or awkward loads such as containers of chemicals; use mechanical aids to assist in lifting.

Personnel Protective Equipment (PPE) for ETP O & M

While planning the list of PPE, the following types of situations should be catered for:

1. Impact / Penetration / Compression while doing maintenance tasks
2. Chemical Handling
3. Heat/cold and wetting
4. Harmful dust
5. Oxygen deficiency
6. Obnoxious odours of decomposing matter

7. Hydrogen Sulphide presence
8. Light (optical) radiation
9. Biological exposure from raw / treated effluents and sludge handling
10. Noise of machines and vibrations.
11. Electric shock
12. Rain / Storm

General List of PPE:

1. Safety Boots with non-skid soles and Steel Toes.
2. Electrical Hazard safety Toe shoes
3. Gas Masks and Face Shields
4. Oxygen meters for ascertaining type of atmosphere in a confined area.
5. Single-use Ear Plugs / Ear-muffs
6. Safety Goggles
7. Helmets / Hard Hats
8. Latex Rubber/ Butyl Rubber/ Fabric / Chemical Resistant Gloves
9. Overall Clothing
10. Aprons for laboratory Personnel
11. Safety Belts
12. First Aid Box
13. Fire extinguishers
14. Respiratory Protective mask with man pack cylinders

Safe Handling of Chemicals

Since handling of chlorine and corrosive chemicals form part of many ETPs, special attention should be given to safe handling of these chemicals.

Safe Handling of Chlorine

Pure chlorine comes in two forms: gas and liquid. Chlorine gas is easily liquefied under pressure. Typically, a commercial cylinder contains liquefied gas under pressure. Chlorine gas has a disagreeable, sharp, pungent, penetrating odour. In airborne concentrations above 1000 parts per million (ppm) it has a greenish-yellow colour. In smaller concentrations it is colourless. Chlorine gas is 2½ times heavier than air and tends to flow downhill and pool in lower areas. Wind and weather, however, will cause a chlorine gas cloud to disperse, spreading it in all directions, even uphill.

Liquid chlorine is a transparent, amber-coloured, oily fluid that is 1½ times heavier than water. Liquid chlorine has a high compression ratio. The ratio of liquid to gas is 1 to 460, which means that 1 L of liquid chlorine expands to form 460 L of pure chlorine gas. The maximum allowable concentration of chlorine a person can be exposed to in an eight-hour period is 0.5 ppm,

Chlorine gas is mainly used as a disinfectant in:

1. Swimming pools
2. Water treatment plants
3. Sewage treatment
4. Community water supplies, including water used for irrigation

Chlorine is also used in:

1. Pulp and paper industries
2. Pool chemical products
3. Cleaning products
4. Mining processes
5. Bleach manufacturing
6. Plastics manufacturing

Chlorine is corrosive. It can burn moist body surfaces such as the eyes, nose, throat, lungs, and wet skin because it forms harmful acids when it reacts with moisture. **Repeated exposure to chlorine does not produce an immunity or tolerance.** Long term exposure to low concentrations of chlorine may cause a gradual decrease in lung efficiency. A single exposure to a high concentration can cause the same effect.

Toxic Effects of Chlorine

(Chlorine gas is not visible as a greenish-yellow cloud at concentrations below 1000 ppm)

Concentration	Effect
0.03 – 0.1 ppm	Range of odour threshold (many specify this as 0.08 ppm)
1 – 3 ppm	May cause mild irritation of the eyes, nose, and throat
3 – 5 ppm	Stinging or burning in eyes, nose, and throat; may cause headache, watering eyes, sneezing, coughing, breathing difficulty, bloody nose, and blood-tinged sputum
5 ppm or more	Severe irritation of the eyes, nose, and respiratory tract
14 – 25 ppm	May be fatal after 30 minutes of exposure
25 ppm or more	Immediate breathing difficulty resulting in pulmonary edema (fluid build-up in lungs), possibly causing suffocation and death 1000 ppm or more Fatal after a few breaths
1000 ppm or more	Fatal after a few breaths

Exposure Limits of Chlorine

Concentration	Effect
0.5 ppm	Maximum allowable concentration averaged over an eight-hour period
1 ppm	Maximum allowable short-term exposure (15 minutes)
10 ppm or more	Immediately Dangerous to Life and Health as published by National Institute for Occupational Safety and Health in the United States (NIOSH).

Handling Chlorine equipment: Changing chlorine cylinders

1. Turn on the light and visually ensure that the room is safe to enter (there may be visible signs of damage).
2. Put on appropriate personal protective equipment (be specific about the type of equipment). This procedure requires a respirator other than an escape respirator
3. Turn on the exhaust ventilation before entering the room.
4. Close the main chlorine container valve.
5. Allow the system to purge itself of chlorine. Ensure that the float drops to the bottom of the feed-rate indicator (rotameter). Verify that there is a high vacuum and that the weigh scale reads zero.
6. Loosen the chlorinator (auxiliary valve or vacuum regulator) and remove it from the empty cylinder.
7. Replace the cylinder cap on the empty chlorine cylinder and remove the cylinder to secured storage.
8. Secure the new cylinder into place.
9. Remove the protective hood from the new cylinder.
10. Ensure that there is no chlorine leaking from the packing gland. Use ammonia vapour from the ammonia test bottle, which contains a strong ammonia solution.
11. Ensure that the cylinder valve is closed. **Do not** open the valve yet.
12. Remove the cylinder outlet cap and check that the cylinder outlet face is clean and smooth.
13. Using a new washer, connect the vacuum regulator or the yoke assembly (be specific for the system in use) to the valve outlet using the supplied wrench only.
Note: Never use oil-based material or water to clean the mating surfaces.
14. Crack open the chlorine cylinder valve and then quickly close it again. This will let enough chlorine into the lines to charge them. The valve should open with no more than a sharp rap from the heel of your hand. **Never** use a “helper” wrench or a larger wrench than the one supplied. If the valve will not open, carefully loosen the packing gland slightly.
15. Check all the connections you have made to ensure there are no leaks. Use the vapour from the ammonia test bottle (see step 10). If a leak is indicated, activate

the leak control procedure (see paragraph serial 2 in leak detection and control below).

16. When no leaks are indicated, open the chlorine cylinder valve no more than half a turn and leave the cylinder wrench on the valve.
17. Open any additional system valves (be specific for your facility) and test for leaks as each stage is charged with chlorine.
18. Check for leaks again with the ammonia test bottle to be sure that everything is in order.
19. Ensure that the alarm system is functioning.
20. Turn off the exhaust ventilation and lights and close the door when you leave.
21. Remove your respirator and other personal protective equipment.

Chlorine Leak detection and control

It has two components:

1. What to do if a leak is indicated after a cylinder change?
2. What to do if the chlorine alarm is activated during routine operation of the system?
 1. If the ammonia test indicates a leak after a cylinder change, follow these steps. (Note that the worker will already be wearing a respirator):
 - a) Immediately close the main cylinder valve.
 - b) As long as the monitor reads less than 10 ppm, the cylinder hook-up procedure may be repeated.
 - c) Open (and close) the main cylinder valve and repeat the ammonia test.
 - d) If a leak is still indicated, make a third and final attempt to get a good seal using a new lead washer.
 - e) If the leak cannot be corrected after three attempts, remove the cylinder from service and contact the supplier. Ensure that there is no leak from this cylinder with the main valve closed. A different cylinder must be connected to the chlorination system.
 - f) Leave the chlorine room and remain nearby to restrict access to the room or provide other assistance, as directed, until the chlorine alarm has automatically shut off.

2. If the chlorine alarm has been activated during routine operation of the system, at least two people must respond. Follow these steps:
 - a) Approach the location cautiously.
 - b) If chlorine gas can be smelled in the open, immediately leave the area and activate full emergency procedures. Do not attempt to turn on the exhaust ventilation.*
 - c) If there is no smell of chlorine gas outside the room, put on respiratory protection and check the monitor readout.
 - d) If the chlorine concentration is less than 10 ppm:
 - i) Put on the appropriate personal protective equipment.
 - ii) Enter the room and close the main cylinder valve.
 - iii) Turn on the ventilation system and leave the area until the alarm stops.
 - iv) While still wearing the respirator, enter the room after the alarm has stopped, isolate the leak, and perform necessary repairs. Remember that all chlorine lines must be free of oil, grease, and moisture before re-opening the chlorine cylinder.
 - e) If the continuous monitor indicates a chlorine concentration greater than 10 ppm, immediately leave the area and activate full emergency procedures. Do not turn on the ventilation system* and do not wait downwind of the building for help to arrive.

Note: Never apply water to a chlorine leak. Moist chlorine is more corrosive than dry chlorine and the leak will worsen rapidly if water is applied to it. Remember also that a chlorine leak never gets better, it always gets worse.

Safety in Handling of Corrosive substances such as Acids, Alkalis

General Chemicals used in Effluent Treatment:

1. Neutralization / pH correction: Hydrochloric acid, Sodium Hydroxide / Lime
2. Coagulant / Settling Aids: Aluminium Sulphate, Ferric Aluminium Sulphate, Ferric Sulphate, Ferric Chloride, these may be independent or in combination with Poly Electrolytes (Polymers).

3. For Specific Ion removal, chemicals required as per chemistry of treatment.
4. Nutrients: Urea, Di-ammonium Phosphate
5. Disinfectant: Chlorine, Bleaching Powder (Sodium Hypo-chlorite), Ozone
6. Adsorption / Absorption: Activated Carbon
7. Ion Exchange – based on the specific ion to be removed.

Few Examples of Corrosive Substances used in ETP

1. Sulphuric acid
2. Chromic acid
3. Stannic chloride
4. Ammonium bi-fluoride
5. Bromine
6. Ammonium hydroxide

General Characteristics of ETP Chemicals

1. Acids and Alkalis fall into the category of Corrosive chemicals. Corrosives are most commonly acids and alkalis, but many other materials can be severely damaging to living tissue.
2. Corrosives can cause visible destruction or irreversible alterations at the site of contact. Inhalation of the vapour or mist can cause severe bronchial irritation. Corrosives are particularly damaging to the skin and eyes.
3. Certain substances considered non-corrosive in their natural dry state are corrosive when wet such as when in contact with moist skin or mucus membranes. Examples of these materials are lithium chloride, halogen fluorides, and alkyl iodide.
4. Sulphuric acid is a very strong dehydrating agent and nitric acid is a strong oxidizing agent. Dehydrating agents can cause severe burns to the eyes due to their affinity for water.

Use and Storage of Corrosives

1. Always store acids separately from bases. Also, store acids in acid storage cabinets away from flammables since many acids are also strong oxidizers.

2. Do not work with corrosives unless an emergency shower and continuous flow eyewash are available.
3. Add acid to water, but never add water to acid. This is to prevent splashing from the acid due to the generation of excessive heat as the two substances mix.
4. Never store corrosives above eye level. Store on a low shelf or cabinet.
5. It is a good practice to store corrosives in a tray or bucket to contain any leakage.
6. When possible, purchase corrosives in containers that are coated with a protective plastic film that will minimize the danger to personnel if the container is dropped.
7. Store corrosives in a wooden cabinet or one that has a corrosion-resistant lining. Corrosives stored in an ordinary metal cabinet will quickly damage it. If the cabinet supports that hold up the shelves become corroded, the result could be serious. Acids should be stored in acid storage cabinets specially designed to hold them and Nitric acid should be stored in a separate cabinet or compartment

Use and Storage of Hydrofluoric Acid

1. Hydrofluoric acid is extremely hazardous and deserves special mention. Hydrofluoric acid can cause severe burns and inhalation of anhydrous hydrogen fluoride can be fatal. Initial skin contact with hydrofluoric acid may not produce any symptoms.
2. Only persons fully trained in the hazards of hydrofluoric acid should use it.
3. Always use hydrofluoric acid in a properly functioning fume hood. Be sure to wear personal protective clothing!
4. If you suspect that you have come in direct contact with hydrofluoric acid: wash the area with water for at least 15 minutes, remove clothing, and then promptly seek medical attention. If hydrogen fluoride vapours are inhaled, move the people immediately to an uncontaminated atmosphere (if safe to do so), keep the person warm, and seek prompt medical attention.
5. Never store hydrofluoric acid in a glass container because it is incompatible with glass.
6. Store hydrofluoric acid separately in an acid storage cabinet and keep only that amount necessary in the lab.
7. Creams for treatment of hydrofluoric acid exposure are commercially available.

Health Hazards Associated with Corrosives:

1. All corrosives possess the property of being severely damaging to living tissues and also attack other materials such as metal.
2. Skin contact with alkali metal hydroxides, e.g., sodium hydroxide and potassium hydroxide, is more dangerous than with strong acids. Contact with alkali metal hydroxides normally causes deeper tissue damage because there is less pain than with an acid exposure. The exposed person may not wash it off thoroughly enough or seek prompt medical attention.
3. All hydrogen halides (HF, HCl, HBr and HI) are acids that are serious respiratory irritants and also cause severe burns. Hydrofluoric acid is particularly dangerous. At low concentrations, hydrofluoric acid does not immediately show any signs or symptoms upon contact with skin. It may take several hours for the hydrofluoric acid to penetrate the skin before you would notice a burning sensation. However, by this time permanent damage, such as second and third-degree burns with scarring, can result.

Acute Health Effects:

Inhalation	irritation of mucus membranes, difficulty in breathing, fits of coughing, pulmonary edema
Ingestion	irritation and burning sensation of lips, mouth, and throat; pain in swallowing; swelling of the throat; painful abdominal cramps; vomiting; shock; risk of perforation of the stomach
Skin Contact	burning, redness and swelling, painful blisters, profound damage to tissues, and with alkalis; a slippery, soapy feeling
Eye Contact	stinging, watering of eyes, swelling of eyelids, intense pain, ulceration of eyes, loss of eyes or eyesight

Chronic Health Effects

Symptoms associated with a chronic exposure vary greatly depending on the chemical. For example, the chronic effect of hydrochloric acid is damage to the teeth; the chronic effects of hydrofluoric acid are decreased bone density, fluorosis, and anaemia; the chronic effects of sodium hydroxide are unknown.

First Aid:

Inhalation	Remove person from source of contamination if safe to do so. Get medical attention. Keep person warm and quiet and do not leave unattended.
Ingestion	Remove person from source of contamination if safe to do so. Get medical attention. Keep person warm and quiet and do not leave unattended.
Skin Contact	Remove person from source of contamination and take immediately to an emergency shower or source of water. Remove clothing, shoes, socks, and jewellery from affected areas as quickly as possible, cutting them off if necessary. Be careful not to get any chemical on your skin or to inhale the vapours. Flush the affected area with water for a minimum of 15 minutes. Get medical attention.
Eye Contact	Remove person from source of contamination as quickly as possible, cutting them off if necessary. Be careful not to get any chemical on your skin or to inhale the vapours. Flush the affected area with water for a minimum of 15 minutes. Get medical attention.
Eye Contact	Remove person from source of contamination as quickly as possible, cutting them off if necessary. Be careful not to get any chemical on your skin or to inhale the vapours. Flush the affected area with water for a minimum of 15 minutes. Get medical attention.

Personal Protective Equipment

Always wear the proper gloves when working with acids. Neoprene and rubber gloves are effective against most acids and bases. Polyvinyl chloride (PVC) is also effective for most acids. A rubber coated apron and goggles should also be worn. If splashing is likely to occur, wear a face shield over the goggles. Always use corrosives in a chemical fume hood.

Plant Performance Monitoring

The following parameters are an essential part of analysis at the on-site laboratory. The location of sampling and the parameters that are required to be tested for are also given in the table below.

1. pH
2. Total Solids (TS)
3. Suspended Solids (SS)
4. Total Dissolved Solids (TDS)
5. Biochemical Oxygen Demand (BOD)
6. Chemical Oxygen Demand (COD)
7. Dissolved Oxygen (DO)
8. Temperature
9. Chlorine Demand
10. Residual Chlorine
11. Mixed Liquor Suspended Solids (MLSS)
12. Mixed Liquor Volatile Suspended Solids (MLVSS) and Sludge Volume Index (SVI)

DAILY TESTING SCHEDULE FOR VARIOUS PARAMETERS (1000 & 1600 HOURS)							
TEST / PA- RAMETER	INLET TO RAW SUMP/ EQT	INLET PST	OUTLET PST	FROM AERATION TANK (S)	INLET TO SST	OUTLET SST	FINAL DIS- CHARGE
pH	✓	✓					✓
TS	✓						✓
SS	✓	✓	✓		✓	✓	✓
TDS	✓					✓	✓
DO	✓		✓	✓			✓
TEMP.	✓			✓			✓
BOD	✓	✓	✓		✓	✓	✓
COD	✓						✓
O&G	✓	✓					✓
Cl₂ DEMAND						✓	
RESIDUAL Cl₂							✓
MLSS				✓			
MLVSS				✓			
SVI						SLUDGE	
ANY SPECIFIC	As required						

Guidelines for Record Keeping

Running Records are required to be kept for various operating machines such as Mechanical Screens, Mechanical Grit Removers, Pumps, Motors, Scrapers, Aerators, Chemical consumption, Chlorine consumption etc. as maintained by the operators and kept at Control Room or duty room of the operators that is closer to the location of the machines.

The records of effluent quality and other laboratory tests are kept in the laboratory as per daily sample collection and testing schedules.

The record with respect to flow need to be maintained by operators as per Table below. The daily log sheet is passed to the Plant Manager on the subsequent day duly signed by the operator in the first shift. All operators shall be responsible to fill up their part of observations and calculations. The Plant Manager shall verify the daily record as well as the calculations and shall be responsible to generate further data using these.

It is pertinent to mention that there shall be a requirement of drawing site specific procedures and formats / forms for keeping records. This shall be the responsibility of the Plant Manager.

Hourly record of Flow as measured / recorded through the Notch/ Weir/ Flow meter:

Date / Time	HEAD OVER THE NOTCH / WEIR	RATE OF FLOW	AVERAGE RATE OF FLOW IN PAST HOUR	FLOW QUANTITY
__/__/__	m ³	m ³ / HOUR	m ³ / HOUR	m ³
0800-			-	-
0900				
1000				
1100				
1200				
1300				
1400				

Date / Time	HEAD OVER THE NOTCH / WEIR	RATE OF FLOW	AVERAGE RATE OF FLOW IN PAST HOUR	FLOW QUANTITY
__/__/__	m ³	m ³ / HOUR	m ³ / HOUR	m ³
1500				
1600				
1700				
1800				
1900				
2000				
2100				
2200				
2300				
2400				
0100				
0200				
0300				
0400				
0500				
0600				
0700				
0800				
Total flow in the past 24 hour; 0800 hrs on October 14 to 0800 on Oct 15, 2004				Σ =

Computations of daily figures for the System:

Date / Month / Year	Daily Flow	Raw Effluent		Treated Effluent		Organic load removed	SS passed into outfall
		BOD	SS	BOD	SS		
	m ³ /day	mg/L	mg/L	mg/L	mg/L	Kg/day	Kg/day

Record of consumption of Electricity from the Energy meter:

Date	Energy Meter Reading At 0800 Hours Daily	Energy Consumed In Past 24 Hours	Rate / Unit Of Energy	Energy Expenses Per Day
	KHW	KHW	Rs.	Rs.
Total for the month		Units. Σ =		Rs. Σ =

Record of monthly Expenses:

HEAD	ITEM	EXPENSES DURING THE MONTH	EXPENSES IN THE PAST MONTH	PROJECTIONS FOR THE NEXT MONTH
		Rs.	Rs.	Rs.
STAFF	SALARIES			
	CONVEYANCE			
	TRAVEL			
	PF BY EMPLOYER			
	ESIS BY EMPLOYER			
	ARREARS OF WAGES			
	TOTAL			
VEHICLES / TRUCKS	FUEL			
	REPAIRS FROM TRADE			
	MAINTENANCE SPARES			
	TOTAL			
PLANT MACHINES/ EQUIPMENT / PIPES / VALVES	SPARES FOR REPAIRS TO INSTALLATION			
	MAINTENANCE FUEL / OILS / GREASES/			
	CIVIL / GARDENING			
	RENEWALS			
	FROM TRADE			
	HIRING			
	TRANSPORTATION			
	TOTAL			
EFFLUENT TREATMENT	STOCK CHEMICALS			
	CHLORINE			
	TOTAL			

HEAD	ITEM	EXPENSES DURING THE MONTH	EXPENSES IN THE PAST MONTH	PROJECTIONS FOR THE NEXT MONTH
		Rs.	Rs.	Rs.
LABORATORY	CHEMICALS & REAGENTS			
	EQUIPMENT			
	INSTRUMENTS			
	GLASSWARE			
	ENERGY			
	FUEL			
	TOTAL			
ENTERTAINMENT	PLANT VISITS			
	OFF PLANT			
	TOTAL			
MISCELLANEOUS	SUNDRY PAYOFFS			
	SUNDRY GIFTS			
	TOTAL			
ANY OTHER				
	GRAND TOTAL			
	FLOW TREATED DURING THE MONTH			
	COST OF TREATMENT/ CUM			

Criteria for appointing Operation & Maintenance Agency

A well-designed ETP may not perform if it is not operated properly. However, as ETP operation is a skilled job requiring expertise in environmental engineering, environmental sciences, mechanical electrical trades, laboratory analysis, and trouble shooting, it may not be possible to undertake ETP operation in-house. Hence, many a times ETP operation is outsourced. Listed below are essential criteria for selecting ETP operating agency:

Statutory registrations & clearance certificates - MUST

1. Recognized Environmental Laboratory u/s.12 of the Environment (Protection) Act, 1986 approved by Ministry of Environment & Forests, Govt. of India, New Delhi
2. Provident Fund
3. Employee State Insurance Scheme
4. Sales Tax
5. Central Excise for Service Tax
6. Income Tax PAN No.
7. Works Contract Tax
8. Maharashtra Jeevan Pradhikaran Contractor for Rs.50 lakhs; or Contract value whichever is less
9. Electrical Contractor for Rs.25 lakhs; or 50% Tender Value whichever is less
10. Public Works Department for Rs.300 lakhs; or Tender Value whichever is less
11. Should have the documented capability to run courses for training of various trades and personnel employed for the operation and maintenance of the STP / ETP Installation, showing details of various courses run by him in the past for own as well as industrial clients.
12. Tax Clearance Certificates - in respect of above wherever applicable

Financial requirement (minimum)

1. Annual turnover of 10 times the Tender Value for the last 3 years
2. At least 3 jobs of 50% of Tender Value in the last 3 years
3. Bank Solvency of Rs.50 lakh or equal to Tender Value, whichever is less

Experience (minimum)

1. Execution of 3 **similar** orders (in respect of process, volume, type of units, scope of work) from Government or reputed Semi-Govt. Company, in last 3 years, for at least 50% flow of tendered Effluent Treatment Plant.
2. Satisfactory job completion Certificate that should have been signed by Executive Engineer or rank above; certifying the detailed scope of work handled to include Electrical Installations, Programmable Logic Control Panels, Pumping Station, Digester, Chlorination and having maintained an on-site Pollution Testing Laboratory.
3. Minimum 1 Post Graduate Environmental Engineer should have been a permanent employee for the last 3 years (Proof in terms of PF / ESIS No. / Salary Returns to be given).
4. Minimum 1 Post Graduate Environmental Scientist should have been a permanent employee for the last 3 years (Proof in terms of PF / ESIS No. / Salary Returns to be given).
