Tamilnadu Water Supply and Drainage Board

Hogenakkal Water Supply and Fluorosis Mitigation Project

Package - II

Volume - 7

Manual for operation and maintenance

MANUAL ON OPERATION AND MAINTENANCE

HOGENAKKAL WATER SUPPLY AND FLUOROSIS MITIGATION PROJECT

1.0 INTRODUCTION

1.1 *Necessity of O&M Manual*

Water is an economic good and is becoming a scarce commodity and as such it shall no longer be considered as a free commodity. Therefore it is one of the most important responsibilities of O & M Personnel to properly maintain the transmission of water in order to prevent waste and provide a constant pressurized flow of potable water to the consumers. It is equally important to prevent damage to the Water Supply System which could arise because of improper operation or improper repairing a defective pipe or pumping machinery and ancillary units. Systematic operations and proper planning and implementation of remedial measures will avoid leakages and breakdowns.This O&M manual is applicable to the installations of this Section of HWS&FMP under Package-II and will keep the standard practices continued even there is change of incumbent.

1.2 *Objective*:

The objective of an efficient operation and maintenance of a Water Supply System is to provide safe and clean drinking water with pre-determined quantity and desired quality and at adequate pressure at convenient location and as economically as possible on a sustainable basis.

This O&M Manual is limited to transportation of treated water available at Madam MBR. This Manual on Operation and Maintenance for Package-II is intended to serve as a guide to strengthening the technical, operational and managerial capabilities to operate and maintain water supply services as per acceptable norms of quantity and quality, sustainability, reliability and cost.

This manual is primarily intended for the managers and technician's in-charge of the operation and maintenance of the Package -II water supply system.

1.3 *O&M requirements*

The following are some of the key issues and requirements that contribute to the good performance of Operation & Maintenance.

- Adequate finance data on Operation & Maintenance
- Suitable Design and good workmanship
- Specialized Multiplicity and taking responsibilities with coordination
- Personnel with adequate training corresponding to system requirement
- Motivation in career
- Evaluation and regular monitoring
- Emphasis on preventive maintenance
- Availability of operation manuals
- Lack of appreciation of the importance of facilities by the community
- Demarcation of responsibilities and mandates within the water supply sub-sector.

2.0 STRATEGY:

2.1 Definition O&M

Operation refers to timely and daily operation of the components of a Water Supply system such as Balancing reservoirs, pumping plant machinery and equipment, conveying mains, service reservoirs and distribution system etc. effectively by various technical personnel, which is a routine function. **The term maintenance is defined as the art of keeping the structures, plants, machinery and equipment and other facilities in an optimum working order**. Maintenance includes preventive maintenance or corrective maintenance, mechanical adjustments, repairs, corrective action and planned maintenance.

2.2 *Strategy for Good O&M*

The minimum requirements for good operation and maintenance are as follows

- Preparation of a plan for operation and maintenance.
- Providing required personnel to operate and maintain.
- Availability of spares and tools for ensuring maintenance.
- Preparation and possession of as built drawing of the system
- Maintaining Master Information System (MIS) records on the system including Technical details of pipes, Pumping Plant and machinery, ancillary units etc

2.3 Better O&M

2.3.1 An institutional study

An institutional study is done wherein the parameters for operating and maintaining the facilities are fixed and the job requirements of various O&M personnel are identified along with their qualifications and or experience. This should also explore possibility of providing on the job training to make up for the lack of qualifications and experience to discharge the job requirements. A realistic assessment of staff required is made and surplus personnel if any are identified. In case of deficit of staff, the possibility shall be examined for entrusting some of the O&M activities to outside agencies on contract basis.

2.3.2 Training

As a result of the institutional study it would be possible to list out the training requirements of individual personnel. Prepare a program of training with time bound targets. Identify the facility to train and prepare training material. Implement the training program. Assess the performance of O&M staff after training. Change or update the training program to suit the situation as per the assessment

2.3.3 Planning for Emergencies

It is possible that normal water supply may be disrupted due to any event, natural or man-made. Such disruptions occur suddenly leaving no time for planning to meet such contingencies. It is therefore essential that an advance plan be prepared to meet such exigencies. Past experience of emergencies in the system as well as of other systems is very useful in drawing up an emergency plan. Some of the events or emergencies that may arise are: power failure, storms and flooding, fire,

earthquakes, explosions, breakdown of water supply system units like pumps and pumping mains, strikes by workmen, sabotage or vandalism and water supply bio-terrorism.

2.3.4 Safety in O&M Operations

Operations in O&M of a Water Supply System also may result in accidents. Hence there is a need for safety practices to be followed by the O&M personnel. Adoption of safe practices and use of safety equipment may largely minimize accidents. Many accidents occur due to the human factor. Though the ultimate responsibility may be that of management, the operator cannot also be relieved of his responsibility. Hence a Safety Program is to be written down for every organization and it must be ensured that everyone in the organization scrupulously follows the safety practices.

2.3.5 Management Information systems (MIS)

Quite often there is an acute dearth of information on material inventories, tools, spares, staffing pattern, costs etc. Hence setting up a Management Information System is one of the most important tasks in the institutional development which could lead to sustainable O&M. The authority must decide what information is important, who is to keep the record, periodicity of reporting system and formats of reporting. MIS is used to analyze and evaluate the performance of system. The MIS could also be used in assigning responsibilities and in distribution of human, material and financial resources to ensure sustainable O&M.

2.4 Limitations of O&M Strategy

- Lack of finance, inadequate data on Operation & Maintenance
- Multiplicity of agencies, overlapping responsibilities
- Lesser attraction of maintenance jobs in career planning
- Inadequate emphasis on preventive maintenance
- Lack of operation manuals
- The facilities may be located at inaccessible places and it may take more time for qualified personnel to reach such places for attending to repairs or replacements.
- In several installations the equipment might have outlived its life
- Neglect or improper operation previously

3.0 TRANSNISSION MAINS

3.1 General

3.1.1 Objective of Transmission of Water

The overall objective of a transmission system is to transmit treated water available at Madam MBR to the storage reservoirs for onward transmission to Union-MBR/MBR& Union Sump/Sumps through Transmission Main up to Uthangarai with several branches to 5 Unions and then to Panchayat MBRs through Internal Transmission Main (also called as ITM). Water so collected in the Panchayat MBRs will be further transmitted to OHTs in the beneficiary habitations / Town panchayats through a net work of pipeline called Internal Net work (also called as INW) for distribution to public. Transmission of water can be either by gravity flow or by pumping.

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

Routine and emergency operating procedures are evolved for all operators with the authority to act in emergencies. Specific operational procedures are further highlighted for inspecting, monitoring, testing, and disinfecting the system as well as for locating the buried pipes and valves. System records and maps have sufficient details of the system facilities

Normally the operations involve transmission of required water within the available head or within the pumping head. Operations of valves at reservoirs from which transmission mains start and operation of pumps (in case of pumping mains) from which the transmission mains start are the routine operations.

I. *Gravity Transmission Main*

Pipe line transmitting water by gravity may by either from a Ground Level Storage sump or from a Break pressure tank (BPT) or from an Elevated Over Head Reservoir.

a) Ground Level Sump / Reservoir

Ground Level sump or Reservoir will receive water from a Sumps or reservoirs located upstream location. Example of this category is Sump at Madam which acts also as a GLS/R for Gravity flow to Mangarai, Kalpambadi . This sump acts as storage sump for further pumping to Koothpadi,Pennagaram Town panchayat . This kind of reservoir receives water during limited pumping hours but designed for gravity flow for 24 Hours.

b) Break Pressure Tank(Ground Level/Elevated)

Normally, these types of tanks are located at Ground Level. Example of this category is BPT At thanakotanahalli BPT in pennagaram Union. Sometimes, they are elevated. Example of this category is BPT at Gendayanhalli Break Pressuretanks are designed for little minute storage. Break Pressure tanks are introduced at ridge points for killing / reducing the pressure on upstream side, there by water is transmitted with less pressure beyond /after the BPT. This helps in minimizing the class of pipe and hence cost of pipes.

a) Elevated Over Head reservoir

In our project, these are commonly called as Master Balancing Reservoir (MBR). Example of this category is Union MBR at Konanginaiyakanhalli. This kind of reservoirs is elevated to suitable height for feeding to OHTs or panchayat MBR. Normally these reservoirs will receive water from a MBR/Booster Pumping Station. Operations of all these type are similar.

A record is kept at the Union MBR about the valve operations, water levels, inflow and out flow. Flow meters are installed at start points of transmission pipes for monitoring the flows. Water levels in the reservoirs from which the pipes transmit water are measured either by visible gauges or by automatic instruments. The panchyat MBRs will transmit water to OHTs located in the beneficiary habitations through one or more outlets. The valve openings in panchayat MBRs are pre-determined during commissioning and Trail run. Mostly, panchayt MBR will function as elevated BPT.

II. *Pumping transmission mains*

Pumping of water is necessitated for lifting water from a lower elevation to a higher elevation. At the receiving point, the structure may be again a sump for further pumping or a BPT or MBR. Water levels in the sumps from which the water is being pumped are measured. In the pumping systems, whenever water pressures in the pumping station drops below the designed system pressure, the operators are alerted to search for possible leaks in the pumping system. At times whenever the maximum levels in the receiving reservoirs are reached the pumps will have to be stopped or the outlet valves of the reservoir have to be opened.

III. *Continuity:*

Operators are required to check that the transmission of water takes place continuously and as per the requirement. Normally, the flow meter readings, water levels in reservoir etc are recorded and transmitted to the control room. The operators have to ensure the accuracy of the measuring instruments for flows, pressures and levels so as to perform the operations properly. Analysis of the records will enable the CONTROL to evaluate how well the transmission system is working.

3.3 TRANSMISSION THROUGH PIPES:

3.3.1 Problems in Transmission through Pipes:

3.3.1.1 Leakages:

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

3.3.1.2 Leak through Appurtenances:

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

3.3.1.3 Air Entrainment

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

3.3.1.4 Water hammer or Surge

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

3.3.1.5 Aging

With age there is considerable reduction in carrying capacity of the pipelines particularly unlined CI, MS and GI pipes resulting in corroded pipes and leaks and hence in reduced quantity and pressures.

3.3.1.6 Lack of Records

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

3.3.2 OPERATION SCHEDULE

3.3.2.1 Mapping and Inventory of pipes and fittings

Keeping /storing as built drawings and maps with design of transmission systems with location of valves, flow meters and pressure gauges is the first requirement for preparation of operation schedule. These maps shall also serve other utility services like electricity, communications etc. with reference to the alignment of transmission.

A detailed LS plan showing the location of all valves is also required and this will help in identifying the location of all appurtenances, hydraulic pressure at appropriate locations, direction of flow, nature of flow, areas of high pressure zone and low pressure zones, areas of special attention needed during charging the pipe line etc.

3.3.2.2 Normal operations

The efficiency and effectiveness of a water supply transmission system depends on the operating personnel's knowledge of the variables that affect the continuity, reliability, and quantity of water transmitted. The operational staff should be able to carry out changes in the hydraulic status of the system as required depending on those variables promptly and effectively.

Routine operations are activities for adjusting the valves and operation of pumps to match the prevailing conditions (flows, pressures, levels and operation of pumps). Valve and pump operations will have to be controlled as per a schedule. The schedule shall contain operations for operating the transmission system. It should contain procedures to obtain, process, and analyze the variables related to water flows, pressures and levels as well as the consequences of manipulating control devices, such as operation of valves and/or pumps so that the hydraulic status of the system can match the required capacity of the system for transmission of water. When operators change their shifts information on valve closure and opening must be exchanged.

3.3.2.3 Operations in abnormal conditions

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

3.3.2.4 Evaluation of Data and Records

A continuous evaluation of the hydraulic conditions of the water supply system can be done by the O&M personnel after obtaining the data on water volumes in the reservoirs, flow meter readings from and into the reservoirs connected to a transmission system and compared with the expected performance. This evaluation shall lead to identification of operational problems and/or system faults. Depending on the type of problems actions have to be initiated to ensure that the system functions as per the requirement.

3.3.2.5 System Pressures

Maintenance of a continuous positive pressure in the mains at the time of transmission of water is required. Locations along the transmission mains which show low pressures have to be promptly investigated if necessary by measuring pressures with pressure gauges. Low pressures may be due to:

i) Purposefully or accidentally a line valve is left closed or partly closed or blockage may occur due to any material causing loss of pressure,
ii) High velocities in smaller diameter pipelines,
iii) Low water levels in service reservoir (SR) feeding into the transmission main,
iv) Failure of pumps either due to power failure or mechanical failure feeding the transmission system.

3.3.3 Simulation

Operations have to be planned for specific circumstances such as failure at source, failure of pumps, leakages or bursts. Criteria have to be determined on the basis of analysis of the effects of particular operations on the hydraulic configuration of the water supply transmission system. These effects can be seen in simulated operating conditions.

Mathematical simulation models can be developed from basic data on the network such as length, size, flow, characteristics of pumps, valves, reservoir levels etc. This approach can be very useful for analyzing the effects of variables on large and complex water supply transmission systems.

3.3.4 System Surveillance

Patrolling or Surveillance of Transmission system is done

- To detect and correct sanitary hazards.
- To detect and correct any deterioration of the transmission system facilities.
- To detect encroachment of transmission system facilities by other utilities such as sewer and storm water lines, power cables, telecom cables etc. and To detect and correct damages to the system facilities by vandalism.

These checks are done routinely. In addition, checks are done under special circumstances for assessing damage of the transmission system after flooding along the alignment following a heavy storm. All these checks are also done for above ground water facilities such as valves and valve chambers or exposed pipelines. Any activity or situation that might endanger the water facility or water quality shall be investigated and corrective action is to be taken.Surveillance shall also include looking for unauthorized construction activity on or near the utility's pipelines which may pose a physical threat to the mains. Any digging or excavation or blasting near the mains shall be closely supervised by the utility staff. Surveillance of Valve chambers and valves of the transmission system shall be done as noted below in para3.3.5.2

3.3.5 Maintenance schedule

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

3.3.5.1 Activities of in Maintenance schedule

Following activities are to be included in the schedule:

1) Develop and conduct a surveillance program for leaks in pipelines, pipe joints and Valves,
2) Develop and conduct a water quality surveillance program,
3) Develop and conduct a program for locating and repairing leaks including rectifying cross connections if any, arrange for flushing, cleaning and disinfecting the mains,
4) Essential information provided by the public and the maintenance teams about the pipeline leaks,
5) Establish repair procedures for standard services and with provision for continuous training of the team members,
6) Procure appropriate machinery, equipment and tools for repair of leaks and replacement of pipes and valves,
7) Allocate suitable transport, tools and equipment to each maintenance team,

8) Establish time, labour and material requirement and output expected, time required and other standards for each maintenance task, and
9) Arrange for monitoring the productivity of each team.

3.3.5.2 Preventive maintenance schedule

A preventive maintenance schedule has to be prepared for:

1. Maintenance of the pipelines with particulars of the tasks to be undertaken, works not completed and works completed,
2. Servicing of valves, expansion joints etc.
3. Maintenance of valve chambers,
4. Maintenance of record of tools, materials, labor, and
5. Costs required carrying out each task.

(2). Servicing of Valves

Seating of Valves which are subject to operations several times is likely to become leaky or pass the flow downstream even after closing tight. Periodical servicing will be required for valves, expansion joints, flow meters and pressure gauges. Corrosion of valves is the main problem in some areas and can cause failure of bonnet and gland bolts. Leaks from spindle rods occur and bonnet separates from the body. Stainless steel bolts can be used for replacement and the valve can be wrapped in polyethylene wrap to prevent corrosion.

(b) List of Spares

A list of spares required for the transmission system shall be prepared and the spares shall be procured and kept for use. The list of probable spares to be kept in stock may include the following:

- Spare check- nuts and spindle rods and assorted bolts; nuts and washers for the flanged joints, gaskets for flanged joints for all sizes of sluice valves installed in the transmission system,
- spare manhole covers and
- Consumables like the gland rope, grease, cotton waste, jointing material like rubber gaskets, spun yarn, pig lead and lead wool.

(c) List of Tools

The necessary tools equipment repair to properly and correct both the routine problems and for facilitating repairs and replacements in a Transmission system have to be identified and provided to the maintenance staff. Some of the tools for the maintenance work in a Transmission system:

Key rods for operation of all sluice valves, hooks for lifting manhole covers, pipe wrench of appropriate sizes (200, 300 or 450 mm) DE spanner set, ring spanner set, screw drivers, pliers, hammers, chisels, caulking tools for lead and spun yarn, ladles and pans for melting and pouring lead joints, excavation tools such as crow bars, spades, iron baskets, buckets and de-watering pumps. In case of large diameter transmission system excavators, cranes, diesel welding sets, welding electrodes, gas cutting accessories and gas cylinders will also be required.

(d) Maintenance of Chambers for appurtenances

Valve chambers shall be checked to ensure that they are not damaged, nor filled up with earth or buried in pavement. Cover of valve chambers are stolen or broken up by vandalism or accidentally leading to damage to the valve itself or will lead to accidental fall into the open valve chamber; such situations have to be corrected on priority. Road improvement works require constant attention of water utility staff since the valves may be lost or at times the valve chambers in the roads have to be reconstructed to match the renewed road surface.Valve Chambers on cross country pipelines are likely to be tampered to collect water and are likely to be affected by floods and agricultural and industrial activities. Leakages at such places will affect the water quality by cross connections and hence these leaks require to be attended on priority.

3.3.6 Maintenance of Pipe lines

3.3.6.1 Main breaks

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

The consumers, through the authority concerned, have to be informed about the probable interruption in water supply and also the estimated time of resumption of water supply. After the closure of the valve, the dewatering/mud pumps are used to drain the pipe break points. The sides of trenches have to be properly protected before the workers enter the pit. The damaged pipe is removed, and the accumulated silt is removed from inside the pipe and the damaged pipe is replaced and the line is disinfected before bringing into use. A report shall be prepared following every pipe break about the cause of such break, the resources required for rectification and the time and cost required for repairing etc. so that the agency can follow up with measures for avoiding such breaks and also modify their plan to address such breaks in future.

3.3.6.2 Flushing of pipe lines

Flushing is done to clean the transmission lines by removing impurities or sediment that may be present in the pipe over a period of time. Routine flushing of pipelines may be necessitated at long intervals before the water quality deteriorates and consumers start complaining. Sometimes checking and corrective measures of operations in the operations of f treatment processes and cleaning of service reservoirs supplying water to the transmission system along with the flushing of distribution system may have to be considered. Flushing is usually done during low water demand periods with good publicity.

3.3.7 Leakage and Waste Control

In the case of transmission mains, the leaks become visible due to the high pressures. Leakage of water in the transmission system occurs by way of leakage from pipes, joints & fittings, reservoirs & overflows of reservoirs & sumps. The objective of leakage control program is to reduce to minimize the time that elapses between the occurrence of a leak and its repair. The volume of water lost through each leak should be reduced by taking suitable action to ensure that the leak is repaired as quickly as possible. Critical areas where leaks often occur have to be identified and appropriate corrective measures have to be implemented.

3.3.8. Cross connections

Contaminated water through cross connections of water supply lines with sewers and drains is a problem prevailing widely. Regular survey along the alignment of transmission system has to be undertaken to identify potential areas likely to be affected by cross connections and back-flow. All field personnel should be constantly alert for situations where cross connections are likely to exist. Densely populated areas and slums without sanitation facilities located along the transmission lines are some of the locations prone for cross connections. After identifying the cross connections, remedial measures are taken up which include: providing horizontal and vertical separation between the water main and the sewer/drain.

3.3.9 Telemetry and SCADA

3.3.9.1 Manual Monitoring

Normally the Managers of O&M of water utilities monitor levels in service reservoirs fed by the transmission system and also monitor the flow meter readings of upstream and downstream reservoirs connected by a transmission system. The pressures of the pipeline at salient points are also monitored. Data on operation of pumps such as hours of pumping and failure of pumps and on water quality by measuring residual chlorine is also monitored. The manager usually uses the telephone line or wireless unit to gather the data, analyses the same and uses his discretion gained with experience and takes decisions to ensure that the system is operating with required efficiency. Manual collection of data and analysis may not be helpful in large undertakings if water utilities have to aim at enhanced customer service by improving water quality and service level with reduced costs. These days acquisition of such data by Telemetry and SCADA is being adopted.

3.3.10 Records and Reports

3.3.10.1 Record system:

A record system is developed which is applicable to the operating problems involved in the Transmission system. Management must be clear as to why the data/ information are collected, as to who will review the data and who will respond to the results of review. The most efficient way to keep records is to plan what data is essential and then prepare the formats followed by guidelines, fill the data, frequency and to send the record to for review and report. Sample records to be maintained are given below for guidance.

i) Updated transmission system map with alignment plan and longitudinal section of the pipeline showing the invert levels and hydraulic grade lines of the pipelines and location of appurtenances, flow meters and pressure gauges,

ii) Record of flow meter readings at upstream and downstream ends of the transmission system,

iii) Record of water levels of the reservoirs at upstream end of the transmission system,

iv) Pressure readings of the pipelines in case of pumping,

v) Review of record of pressures and flows,

vi) Identify the persistent low pressures in the transmission system,

vii) Identify the source of leaks,

viii) Identify the persistent leak points,

ix) Status of bulk meters – functional status,

x) Identify the residual chlorine levels at designated locations on the transmission system,

xi) Record on when the pipeline leaks were repaired or pipes changed

xii) Record on when the gland ropes of the valves were changed

xiii) Record on when the spares of the valves were changed

xiv) Record on when the expansion joints were serviced

xv) Record on when the exposed piping was last painted

3.3.11 Reports

The report can identify the deficiencies in the system and its appurtenances and then plan future repairs to the transmission system, valves and other equipment or for replacement of defective valves or other equipment.A program has to be prepared for each zone of the transmission system which shall contain procedures for routine tasks, checks and inspections at intervals viz. Daily, weekly, quarterly semi-annually or annually. This plan shall fix responsibility, timing for action, ways and means of completing the action as to when and who should take the action and the need to take these actions. Simple checklists for use by the managerial staff can be prepared to ensure that the O&M staff have completed the tasks assigned to them.

3.4 REPAIR WORKS IN PIPE LINE

It is one of the most important responsibilities of Personnel of O&M of pipe to properly maintain the transmission and distribution mains in order to prevent waste and provide a constant pressurized flow of potable water to the consumers. It is equally important to prevent damage to the public property which could arise for not properly repairing a defective pipe. Proper planning and implementation of remedial measures will avoid leakages and breakdowns.

3.4.1 Failure at Joints

Some of the points for consideration are given below:

3.4.1.1 General

- Failures may occur due to originally careless installation practices causing displacements of the seal and/or eventual separation of the mating surfaces.
- Stress cracking of pipe material around the joint.

- Biodegradation of the sealing components.

3.4.1.2 Flanged Connections

Stress cracking of the flange can occur due to unequally tightened bolts. Such a situation arises during ground movement or the forceful activation of a valve.

3.4.1.3 Crushing of pipe ends

Cracking may occur due to crushing of pipe ends when they touch or bind and are then subjected to high compressional or bending forces.

3.4.1.4 Sealing rings or gaskets

Many mechanical joint designs rely upon the compression of sealing rings or gaskets which have varying compositions and different resiliencies. The physical breakdown (e.g. biodegradation) or change of resilience with time can lead to leaking joints. The loss of compression combined with corrosion of pressure rings or collars or the bolts may aggravate the breakdown.

3.5 ACTION PLAN FOR PIPE LINE REPAIR

3.5.1 General Procedure

Following procedure may be followed:

1. Internal mobilization.
2. Detection of pipe failure: Inspection of site
3. Notification of interruption in water supply and related issues.
4. Location and demarcation
5. Repair planning
6. Repair work
7. Restoration
8. Completion
9. Notice of restoration and completion

3.5.2 Initial Mobilization

Some of the important activities relating to the mobilization of the activities are summarized below;

(a) **Senior Level Management**

Necessary information to the Senior Level Management may be submitted and their interim approval sought. Details approval can follow in due course of time.

(b**) Operation and maintenance staff of the running water supply system**

The entire staff must be made fully aware of the likely activities required to be undertaken so as to ensure minimum possible interruption in the system.

(c) **Existing installations**

The operation of the water supply system with regard to Intake, Head works, pumping machinery, Treatment Plant, Piping system etc. must be co-related with the proposed repair work.

(d) **Mobilization of men**

Necessary staff may be arranged for the following duties;

1. Location of section;

2. Isolation of section;

3. Scouring of section;

4. Arranging transport, material, machinery, equipment, tools, pipes, fittings etc.

5. Other miscellaneous duties.

(e**) Manpower, material, machinery, transport, lighting, safety measures, communication, pipes with**

fittings and specials etc. for the repairing operation.

These details are variable and depend upon various factors as per the local situation.

Some of the factors to be considered are;

i) The importance, utility and function of the affected pipeline with the piping net work. This may be the only transmission main of the system. It may be one of the two or many parallel transmission mains. It may be initial portion of the distribution system serving as the only main to supply water to the rest of the area to be served. It may be a distribution pipe serving only a part of the system.

ii) Size and material of the affected pipe. These are very important factors which determine the magnitude of the repair to be taken.

iii) Depth of the pipeline. Deeper pipes require more labour work for repairing.

iv) Sub-soil water table. If the pipe is laid much below the local water table, additional work will be required to dewater the trenches excavated for repair.

(v) Other unforeseen factors.

Depending on these factors the requirement of manpower, material, machinery, tools, equipments, pipes, specials, fittings etc. is to be worked out. Given below is a list to meet the requirement of big transmission main which is a life for the water supply system. This may be considered as a guideline only. Exact requirement may be worked out depending upon the local conditions.

Electrodes, Gaskets, Rubber insertion, Bolts and nuts, Gland rope, Manila rope, Pig lead, Cottonwaste, Woodensleepers, PVC hose pipe, Canvas hose, Engine oil, Wire slings, Grease, M.S.Plates,Diesel, Kerosene, Fire wood, Cement, Sand, Spun yarn, Hardcrete, M- seal, Sand bags. Scour rod with lever, motor driven pipe cutter with extra cutters, H.T. wire cutter, sheet cutter, screw jacks, hammers, spades, buckets, baskets, crow bars, hammers, shovels, caulking tools and spun yarn for caulking, cement caulking, lead caulking), power wrenches 36 in. to 15 in., adjustable spanner 18 in. to 12 in., chain tong 36 in. long, ring spanner set, DE spanner set, screw drivers, cutting plier, knife, nose plier, knife, chisels, lead pan with sport and bucket, Temporary platforms, files, bench vice and pipe vice.

MS gap special, MS barrels, MS split collars (different types available), MS girder, and MSangle. Wireless set, mobile wireless set and cell phone. Flood lighting, tube light fittings, wire, 3 core cable, insulation tape, main switch, fuse wire, kit- kats, welding cable, emergency lights, torch lights, gas lights, First aid box, helmets, headlight, gum shoes, hand gloves (rubber, leather), gas masks, Oxygen cylinder, Tents, water cans, jugs and glasses, tarpaulins, electric heaters, rain coats etc

3.5.3 Detection of Pipe failure

1. Inspect site and ascertain the nature of the failure.
2. Assess damages/repairs
3. Investigate the access to the site so as to plan the arrangement of plant and equipment.
4. Assess urgency of repair, availability of men and equipment, effect on consumers
5. Locate isolating valves for proper control of requisite activities required for repair work.
6. Prevention of possible contamination of the pipeline
7. Quick location of the actual position of the pipeline.
8. Establish control and communication network after deciding repair work to be undertaken.
9. Safety measures at spot like barricading, warning posts etc diversion of traffic, if required in association with local authorities
10. Mobilize men, material and equipment for repairs.

3.5.4 Notification

Issue notices to the affected consumers and the departments looking after other affected facilities like telephones, cables, electric lines, traffic control etc.

Such notifications may be by mobile loud speakers, local media channels etc.

The contents of the notification will be as under:

- Time of closure and affected area;
- A brief and simple reason for interruption;
- An estimated time of restoration of supplies;
- Contact point for any problems;
- Advice on conservation, flushing, boiling, etc.

3.5.5 Location and assessment of failure

(a) **Location of the failure**

Make use of local knowledge, plan and experience in locating the failure.

(b) **Protective signs**

Before undertaking any excavation work, all protective measures may be taken including signs, lighting etc. Traffic rules must be complied with. All local utilities must be located and marked and liaison kept with local representatives of these affected utilities.

(c**) Excavation**

The conventional methods of excavation may be supplemented with more mechanized processes keeping in view the existence and location of the water main.

(d) **Shuttering and support**

Pay due attention to safety below ground by providing support to trench sides and any exposed pipes and cables.

(e) **Extent of failure**

The full extent of damage, both to pipe work and any support works, should be assessed.

(f) **Work space**

Ample workspace should be created to allow for:

i) Detailed inspection around the pipe.

ii) Provision of sump for continuous operation of a drainage pump

iii) Movement of men with jointing material and equipment to be used safely and effectively.

(g) **Provide safe dewatering system and discharge points**

The discharge of any dewatering apparatus should be checked to ensure free outflow and to avoid any danger or inconvenience caused by flooding.

(h) **Control by Valves**

Ensure effective operation of repair work by proper control of valves which should be in perfect Working condition.

3.5.6 Repair planning

(a) **Note details of existing pipe**

The full details of the failed pipe and/or fitting should be noted including material type, approximate age, class and general condition. Reasons for failure should be established as accurately as possible and recorded. Check actual external dimensions of the pipe and determine any tendency to ovality for effective repair

(b) **Type of repair–wet or dry**

A 'wet' repair is defined as a repair which can be achieved while maintaining a nominal pressure in the pipeline. Split collars or identical fittings can be installed in this way if the conditions are favorable.

A 'dry' repair is defined as one in which the main is completely isolated and drained out. 'Cut out 'repairs necessitating the removal of a section of the pipe and/or joints will require 'dry' main on which to work and the pipeline should be drained out.

(c) **Extent of repair work and availability of repair fittings and tool**

The replacement pipe and/or repair fittings should be selected and their dimensions marked on the pipeline. For a 'dry' repair a final check should be made that all the required fittings and Materials are available and are compatible before any attempt to cut the same is made.

(d**) Bedding material**

Assess and make available the bedding material if required.

(e) **Report to Control**

When ready to start repair, inform 'control'.

3.5.7 Repair Work

(a) **Repair of small, local defects - 'wet repair'**

For small local defects such as pinholes a single split collar or wraparound clamp may be all that is required. The repair can be carried out at as a 'wet' or 'dry' operation. In case of 'wet' repair care should be taken to maintain a steady, gentle flow so as not to dislodge the sealing elements.

(b) **Cut out – 'dry repair'**

For a more extensive damage e.g. a longitudinal fracture, a section of pipe is cut out and replaced by the use of two appropriate couplers. If full extent of the fracture is not clearly defined cuts should be made at least 300mm beyond each end of the visible crack or defect and in case of any doubt the full length of damaged pipe should be replaced. This necessitates cutting out the joint at both ends of the affected pipe, thus the repair normally requires two replacement pipe sections and three couplers.

(c) **Replacement repairs- following observations are important**

- Carryout correct measurements and give allowance for expansion;
- All cuts should be made clean and square;
- All cut edges should be prepared (scraped, de-burred, chamfered etc.) to the manufacturer's Recommendations.
- Both exposed ends of the existing pipe should be similarly treated;
- Couplers should have their sealing rings lubricated if recommended;
- Correct expansion gaps should be allowed;
- Good alignment is essential particularly if narrow couplers are used;
- All couplers and collars should be centralized;
- Tighten all bolts evenly;
- Do not over tighten bolts or compression joints;
- Restore any damaged coatings on the parent pipe;
- Ensure full protection to the bolts and any exposed bare metal before burial.

(d) **Record of repair**

While the repair is still visible the details of repair should be recorded.

(e) **Record of pipe**

Record the following items:

i) any visible damage to the pipe;

ii) state of protective system or coating;

iii) depth of cover

iv) description of the soil/backfill.

3.5.8 Testing of Dry Repair

(a) Give additional support to repaired pipe portion, if necessary;

All wet slurry should be removed to the extent possible, and the bottom of the excavation should be filled and the exposed pipe work rebedded, with suitable material sufficiently compacted to give adequate support to the invert and lower quadrants of the pipe and any fittings.

(b) Renew bedding and compact

Additional material may be placed to support the repaired pipeline when under test pressure, but it is advisable to leave all joints visible in case of leakage.

(c) Arrange air bleeding and slowly refill isolated section

Refilling the isolated section of the main with water should be done slowly and from one direction only. Arrangements should be made for the expulsion of the air by means of any convenient air valves, hydrants, washouts or taps. The repaired pipe is subjected to a pressure equivalent to the normal working pressure. The repaired pipe should remain under such working pressure until it is adjudged to be satisfactory. Some minor re-tightening of the joints may be necessary due to slight expansive movement of the assembly on being subjected to increase in pressure.

(d) Control – Report situation to 'Control'.

3.5.9 Restoration

(a) Restore valves and the system in accordance with the original operational plan. The repaired section of main is reintroduced to the system by restoring all valves to their original status.

(b) Checking restoration

The restoration of the supplies to the normal situation supplied at important points should be checked.

(c) Removal of temporary supplies

All standby pipes, temporary supplies and emergency tankers should be removed.

(d) Notification

Notification and acknowledgments should be made wherever necessary.

3.5.10 Completion

(a) **Finishing touches**

Wherever joints have been left exposed for testing purposes these should be restored to their original position. The bolts, bare metal surfaces etc. should be properly protected prior to side fill.

(b) **Side filling work should be suitably accomplished**

The dug material should be returned to the trench and placed in layers. The first side fill layer should be placed and compacted under the lower quadrants of the pipe and up to the springing level of the pipe. Successive layers of up to 100 mm thickness may then be placed and compacted to a maximum height above the crown of 250 mm.

(c) **Clear site**

On completion of the work all materials and protective barriers should be removed from site and the working area left clean and tidy. All records should be completed and submitted.

3.5.11 Notice of completion

Notice of completion or interim or permanent reinstatement must be given within a reasonable period. Location of works and other relevant details should also be given.

3.5.12 Record of Repair

After completion of the repair work and notification, record the details of work

3.5.13 Review of Records

Records of repair are maintained for Transmission Main/Feeder Main and ITM &INW. The records of repair are reviewed periodically, at least annually. The review may indicate weak section of pipeline, improper operations of appurtenances, area of contaminations, critical sections which require intensive surveillance, procurement decision of spares and tools etc

4.0 OPERATION AND MAINTENANCE OF PUMPING MACHINERY

4.1 Introduction

Pumping machinery and pumping stations are very important components in a water supply system. Pumping machinery is subjected to wear, tear, erosion and corrosion due to their nature of functioning and therefore they are vulnerable for failures. Generally more number of failures or interruptions in water supply is attributed to pumping machinery than any other component. Therefore, correct operation and timely maintenance and upkeep of pumping stations and pumping machinery are of vital importance to ensure water supply with least un-interruptions. Sudden failures can be avoided by timely inspection, follow up actions on observations of inspection and planned periodical maintenance. Downtime can be reduced by maintaining inventory of fast moving spare parts. Efficiency of pumping machinery reduces due to normal wear and tear. Timely action for restoration of efficiency can keep energy bill within reasonable optimum limit. Proper record keeping is also very important.Due attention needs to be paid to all such aspects for efficient and reliable functioning of pumping machinery. This part of the Manual elaborates procedures for operation and maintenance and addresses pertinent issues involved in O&M of pumping machinery and associated electrical and mechanical equipment.

4.2 Components in pumping station

The components in pumping station can be grouped as follows.

i) Pumping machinery

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

ii) Ancillary Equipment

- Lifting equipment
- Water hammer control device
- Flow meter/Water meter
- Diesel generating set

iii) Pumping station

- Sump
- Well(Suction well)
- Pump house
- Penstock/Gate Valve
-

4.2.1 Pumping Machinery

- Operation including starting and stopping of pumps and associated electrical and mechanical equipment
- Preventive maintenance
- Trouble shooting
- Inventory of spares, oil and lubricants

- Tools and testing equipments
- Inspection and testing
- Record keeping

4.2.2 Ancillary equipment

- Operation, maintenance and testing of lifting equipment
- Water hammer (surge) control device

4.2.3 Pumping station

- Maintenance of following,

i) Penstock/gate

ii) Pump house

iii) Housekeeping

4.3 OPERATIONS OF PUMP-SETS

4.3.1 Important Points for operation

Following are important points to be followed/ observed while operating the pumps.

a) Dry running of the pumps should be avoided.

b) Centrifugal pumps have to be primed before starting if needed

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

- If pump is operated at point away from duty point, the pump efficiency normally reduces.
- Operation near the shut off should be avoided, as the operation near the shut off causes substantial recirculation within the pump, resulting in overheating of water in the casing and consequently, in overheating of the pump.

d) Voltage during operation of pump-motor set should be within + 10% of rated voltage. Similarly current should be below the rated current as per name plate on the motor.

e) Whether the delivery valve should be opened or closed at the time of starting should be decided by examining shape of the power-discharge characteristic of the pump. Pump of low and medium specific speeds draw lesser power at shut off head and power required increases from shut off to normal operating point. Hence in order to reduce starting load on motor, a pump of low or medium specific speed is started against closed delivery valve. Normally the pumps used in water supply schemes are of low and medium specific speeds. Hence, such **pumps need to be started against closed delivery valve.** The pumps of high specific speed draw more power at shut off. Such pumps should be started with the delivery valve open.

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

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

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

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

(j) The running of the duty pumps and the standby should be scheduled so that no pump remains idle for long period and all pumps are in ready-to run condition. Similarly unequal running should be ensured so that all pumps do not wear equally and become due for overhaul simultaneously.

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

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

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

4.3.2 Undesirable operations

Following undesirable operations should be avoided.

a) Operation at Higher Head

The pump should never be operated at head higher than maximum recommended. Such operation results in excessive recirculation in the pump, overheating of the water and the pump. Another problem, which arises if pump is operated at a head higher than the recommended maximum head, is that the radial reaction on the pump shaft increases causing excessive unbalanced forces on the shaft which may cause failure of the pump shaft. As a useful guide, appropriate marking on pressure gauge be made. Such operation is also inefficient as efficiency at higher head is normally low.

b) **Operation at Lower Head**

If pump is operated at lower head than recommended minimum head, radial reaction on the pump shaft increases causing excessive unbalanced forces on shaft which may cause failure of thepump shaft. As useful guide, appropriate markings on both pressure gauge and ammeter be made. Such operation is also inefficient as efficiency at lower head is normally low.

c) **Operation on Higher Suction Lift**

If pump is operated on higher suction lift than permissible value, pressure at the eye of impeller and suction side falls below vapour pressure. This results in flashing of water into vapour. Thisvapour bubbles during passage collapse resulting in capitation in the pump, pitting on suction side of impeller and casing and excessive vibrations. In addition to mechanical damage due to pitting, discharge of the pump also reduces drastically.

d) **Throttled operation**

At times if motor is continuously overloaded, the delivery valve is throttled to increase head on the pump and reduce power drawn from motor. Such operation results in inefficient running as energy is wasted in throttling. In such cases, it is preferable to reduce diameter of impeller which will reduce power drawn from motor.

e) **Operation with Strainer/Foot Valve Clogged**

If the strainer or foot valve is clogged, the friction loss in strainer increases to high magnitude which may result in pressure at the eye of the impeller falling below water vapour pressure, causing cavitation and pitting similar to operation on higher suction lift. The strainers and foot valves should be periodically cleaned particularly during monsoon.

f) **Operation of the Pump with Low Submergence**

Minimum submergence above the bell mouth or foot valve is necessary so as to prevent air entry into the suction of the pump which gives rise to vortex phenomenon causing excessive vibration, overloading of bearings, reduction in discharge and efficiency. As a useful guide the lowest permissible water level be marked on water level indicator.

g) **Operation with Occurrence of Vortices**

If vibration continues even after taking all precautions, vortex may be the cause. All parameters necessary for vortex-free operation should be checked. Chapter 11 in Manual on Water Supply and Treatment discusses these aspects in details.

4.4 Starting the pumps

Checks to be carried before starting

Following points should be checked before starting the pump.

- Power is available in all 3 phases.
- Trip circuit for relays is in healthy state
- Check voltage in all 3 phases. The voltage in all phases should be almost the same and within + 10% of rated voltage, as per permissible voltage variation.
- Check stuffing box to ensure that it is packed properly.
- Check and ensure that the pump is free to rotate.
- Check over-current setting if the pump is not operated for a week or longer period.
- Before starting it shall be ensured that the water level in the sump/intake is above low water level and
- In-flow from the source or preceding pumping station is adequate.

4.5 Starting and operating the Pumps

Procedures for starting and operation of different types of pumps are as follows.

(a) Centrifugal Pump

- To start a centrifugal pump, the suction pipes and the pump should be fully primed irrespective of the fact whether the pump is with positive (flooded) suction or suction lift. The centrifugal pump with positive suction can be primed by opening valve on suction side and letting out air from the casing by opening air vent.Centrifugal pump on suction lift necessitates close attention to prime the pump fully. To achieve this, the suction pipe and the pump casing must be filled with water and entire air in suction piping and the pump must be removed. If vacuum pump is provided, the pump can be primed by operating vacuum pump till steady stream of water is let out from delivery of vacuum pump. In absence of vacuum pump, priming can be done by pouring water in casing and evacuating air through air vent or by admitting water from pumping main by opening bypass of reflux valve and delivery valve. Check all joints in the suction pipe and fittings.
- Turn the pump shaft by hand to ensure that parts do not bind
- Close the delivery valve and then loosen slightly.
- Switch on the motor, check that direction of rotation is correct. If the pump does not rotate, it should be switched off immediately.
- Check vacuum gauge if the pump operates on suction lift. If the pointer on gauge gradually rises and becomes steady the priming is proper.
- Pressure gauge should be observed after starting the pump. If the pump is working correctly the delivery pressure gauge should rise steadily to shut off head.
- When the motor attains steady speed and pressure gauge becomes steady, the delivery valve should be gradually opened in steps to ensure that the head does not drop below recommended limit. (in the absence of recommendations, the limit shall be about 85% of duty head for centrifugal pump).
- Check that ammeter reading is less than rated motor current.
- Check for undue vibration and noise.
- When in operation for about 10-15 minutes, check the bearing temperature, stuffing box
- Packing and leakage through mechanical seal and observe vibrations, if any.
- Voltage should be checked every half an hour and should be within limit.

(b) Submersible Pumps

- Close delivery valve, and then loosen slightly.
- Open the air vent in discharge/delivery pipe.
- Switch on the motor and check correctness of direction of rotation. If the pump does not rotate, it should be switched off immediately.
- Check pressure gauge reading to ensure that pump has built up the required shut- off head.

- When the motor attains steady speed and pressure gauge becomes steady, the delivery valve should be gradually opened in steps to ensure that the head does not drop below recommended limit. (In absence of recommendation, the limit shall about 75% of duty head for submersible pump).
- Check that ammeter reading is less than rated motor current.
- Check for undue vibration and noise.
- Voltage should be checked every half an hour and should be within limit.

4.6 Stopping the pump

4.6.1 Stopping the pump under normal conditions

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

- Close the delivery valve gradually (sudden or fast closing should not be resorted to which can give rise to water hammer pressures).
- Switch off the motor.

4.6.2 Action to be taken on Power failure/Tripping

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

Following procedure should be followed.

- Close all delivery valves on delivery piping of pumps if necessary, manually as actuators cannot be operated due to non-availability of power.
- Check and ensure that all breakers and starters are in open condition i.e. off- position.
- All switches and breakers shall be operated to open i.e. off-position.
- Information about power failure should be given to all concerned, particularly to upstream
- Pumping station to stop pumping so as to prevent overflow.

4.7 Preventive maintenance of Pumping Machinery

Lack of preventive and timely maintenance or poor maintenance can cause undue wear and tear of fast moving parts, and premature failure of the equipment. Such premature failure or breakdown causes immense hardship to the consumers and staff, and avoidable increase in repair cost. The shortcomings in maintenance can also result in increase in hydraulic and power losses and low efficiency.

Inefficient running of the pump increases burden of power cost. Importance of preventive maintenance, therefore, need not be overstressed.

Appropriate maintenance schedule and procedure need to be prescribed for all electrical and mechanical equipment based on manufacturers' recommendations, characteristics of the equipment, site and environment conditions i.e. temperature, humidity, dust condition, etc. The maintenance schedule also needs to be reviewed and revised in the light of experience and analysis of failures and breakdown at the pumping station. The preventive maintenance schedule shall detail the maintenance to be carried out at regular intervals i.e. daily, monthly, quarterly, half yearly, annually etc. or operation hours. The schedule shall also include inspections and tests to be performed at appropriate interval or periodicity.

General guidelines for maintenance schedules for pumps and associated electrical and mechanical equipment are enlisted below. The guidelines should not be considered as total, full-fledged and comprehensive as characteristics of equipment and site conditions differ from place to place. For example, in dust laden environment or places where occurrence of storms are frequent, blowing of dust in motor, renewal of oil and grease in bearing shall have to be done at lesser intervals than specified in general guideline.

4.8 Maintenance of Pumps

4.8.1 Daily observations and maintenance

(a) **Daily Maintenance**

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

(b) **Routine observations of irregularities**

The pump operator should be watchful and should take appropriate action on any irregularity noticed in theoperation of the pumps. Particular attention should be paid to following irregularities.

- Changes in sound of running pump and motor
- Abrupt changes in bearing temperature.
- Oil leakage from bearings
- Leakage from stuffing box or mechanical seal
- Changes in voltage
- Changes in current
- Changes in vacuum gauge and pressure gauge readings
- Sparks or leakage current in motor, starter, switch-gears, cable etc.
- Overheating of motor, starter, switch gear, cable etc.

© Record of operations and observations

I. A log book should be maintained to record the hourly observations, which should cover the following items in Form-3 Timings when the pumps are started operated and stopped during 24 hours.

II. Voltage in all three phases.

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

IV. Readings of vacuum and pressure gauges.

V. Water level in sump.

VI. Flow meter reading.

VII. Daily PF over 24 hour's duration.

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

4.8.2 Monthly Maintenance

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

4.8.3 Quarterly Maintenance

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

4.8.4 Annual Inspection and Maintenance

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

- Clean and flush bearings with kerosene and examine for flaws developed, if any, e.g. corrosion, wear and scratches. Check end play. Immediately after cleaning, the bearings should be coated with oil or grease to prevent ingress of dirt or moisture.

- Clean bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in Bearing housing
- Examine shaft sleeves for wear or scour and necessary rectification. If shaft sleeves are not used, shaft at gland packing should be examined for wear.
- Check stuffing box, glands, lantern ring and mechanical seal and rectify if necessary.
- Check clearances in wearing ring.

Clearances at the wearing rings should be within the limits recommended by the manufacturer. Excessive clearance reduces discharge and efficiency of the pump. If the wear is only on one side, it is indicative of misalignment. If the wear is more in all, the rings may be replaced. The misalignment should be set right, and the causes of misalignment should be investigated. When the clearances have to be restored, general guidelines detailed in table 11.1 below shall be followed. Normally, if the clearance in wearing rings increases by about 100% for small pumps and 50-75% for large pumps the rings shall be renewed or replaced to restore to the original clearance.

The tolerances given in the table are to be strictly followed. For example, while machining the internal diameter of the casing wearing ring of basic size, say 175 mm, the limits for machining would be 175.00 minimum and 175.05 maximum. For the corresponding outer diameter at the hub of the impeller or impeller ring, the basic size will be with a clearance of 0.4 mm, i.e. 174.60 mm and the machining limits will be 174.60 mm maximum and 174.55 minimum.

Taking into consideration that part dismantling of the pump is involved in checking wearing ring clearance and as it is not advisable to dismantle vertical turbine pump every year, the frequency for checking wearing ring in case of V.T. pump shall be once in two years or earlier if discharge test indicates discharge reduction beyond limit of 5% - 7%.

- Check impeller hubs and vane tips for any pitting or erosion.
- Check interior of volute, casing and diffuser for pitting, erosion, and rough surface.
- All vital instruments i.e. pressure gauge, vacuum gauge, ammeter, voltmeter, watt- hour meters; frequency meter, tachometer, flow-meter etc. shall be calibrated.
- Conduct performance test of the pump for discharge, head and efficiency.
- Measures for preventing ingress of flood water shall be examined. Ingress of flood water in sump, or suction well shall be strictly prevented.
- Check vibration level.

4.8.5 Overhaul of pump

It is difficult to specify the periodicity or interval for overhaul in the form of period of service in months/years or operation hours, as deterioration of pump depends on nature of service, type of installation i.e. wet-pit or dry-pit, quality of water handled, quality of material of construction, maintenance, experience with particular make & type of pump etc. However generally, following operational hours may be taken as broad guidelines for overhauling.

- Submersible pump – 12000 –15000 hours
- Vertical turbine pump – 25000 hours
- Centrifugal pump – 25000 hours

4.9 History Register for Pumps

History sheet of all pumps shall be maintained. The history sheet shall contain all important particulars, records of all maintenance, repairs, inspections and tests etc. It shall generally include the following.

- Details of the pump, rating, model, characteristic curves, performance test report etc.
- Addresses of manufacturer & dealer with phone & fax number and e-mail addresses.
- Date of installation and commissioning.
- Brief details and observations of monthly, quarterly and annual maintenance and inspections.
- Details of breakdown, repairs with fault diagnosis, replacement of major components i.e.
- impeller, shaft, bearings, wearing rings.
- Results of annual performance test including discharge and efficiency.
- Yearly operation hours of the pumps.
- History register for centrifugal pump is in Form-4
- History register for centrifugal pump is in Form-6

4.10 MAINTENANCE SCHEDULE FOR MOTORS

4.10.1 Daily Maintenance

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

4.10.2 Monthly Maintenance

- Check Coupling. In case coupling bolt nuts are in tense or not
- Blow dust from the motor.
- Check functioning and connections of anti-condensation heater (space heater).
- Check insulation resistance by meggering.

4.10.3 Quarterly Maintenance

- Check insulation resistance of the motor.
- Check tightness of Coupling, cable gland, lug and connecting bolts.
- Check and tighten foundation bolts and holding down bolts between motor and frame.
- Check vibration level with instrument if available; otherwise by observation.

4.10.4 Half-yearly Maintenance

- Clean winding of motor, bake and varnish if necessary.

4.10.5 Annual Inspection and Maintenance

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

4.10.5 History Register for Motors

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

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

- **4.11 VALVES**

Following 5 types of valves are generally used in pumping installation

a) Sluice valve.

b) Reflux (non-return) valve.

c) Butterfly valve.

Maintenance as follows shall be carried out.

4.11.1 Sluice valve and Knife gate valve

- Check gland packing of the valve at least once in a month. It should be ensured that packings inside the stuffing box are in good trim and impregnated with grease.

  It may be necessary to change the packing as often as necessary to ensure that the leakage is within limit.
- Grease should be applied to reduction gears and grease lubricated thrust bearing once in three months.
- Check tight closure of the valve once in 3 months.
- A valve normally kept open or closed should be operated once every three months to full travel of gate and any jamming developed due to long disuse shall be freed.
- Inspect the valve thoroughly for flaws in guide channel, guide lugs, spindle, spindle nut, stuffing box etc. once in a year.
- Important DON'T for valve is that it should never be operated with oversize hand-wheel or cap or spanner as this practice may result in rounding of square top and hand-wheel or cap or spanner may eventually slip.
- An important DON'T for valve is that it should never be operated under throttled i.e. partially open condition, since such operation may result in undue chatter, wear and failure of valve spindle.

4.11.2 Reflux (non-return) valve

- Check proper operation of hinged door and tight closure under no-flow condition once in 3months.
- The valve shall be thoroughly inspected annually. Particular attention should be paid to hinges and pins

  and soundness of hinged door.
- Condition of dampening arrangement should be thoroughly examined once in year and necessary maintenance and rectification as per manufactures' instructions shall be carried out.
- In case of dampening arrangement, check for oil leakage and replace oil once in a year.

4.11.3 Butterfly valve

- Check seal ring and tight shut-off once in 3 months.
- Lubricate gearing arrangement and bearing once in 3 months.
- Inspect the valve thoroughly including complete operations once in a year.
- Change oil or grease in gearing arrangement once in a year.

4.11.4 General (for all valves)

- Operate bypass valve wherever provided once in 3 months.
- Flange adapter/dismantling joint provided with valve shall be loosened and retightened once in 6 months to avoid sticking.

4.12 VALVE ACTUATORS

4.12.1 Quarterly Maintenance

- De-clutch and operate manual hand-wheel.
- Check oil level and top up if required.
- Re-grease the grease lubricated bearing and gear trains as applicable.
- Check insulation resistance of the motor.
- Check for undue noise and vibration and take necessary rectification measures.
- Tighten limit switch cams and check for setting and readjust if necessary.

4.12.2 Annual Inspection and Maintenance

- Examine all components and wiring thoroughly and rectify as necessary.
- Change oil or grease in gear box and thrust bearing.
- Check condition of gears & replace gears if teeth are worn out.

4.13 L.T STARTERS, BREAKERS AND PANEL

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

4.13.1 Daily

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

4.13.2 Monthly

- Blow the dust and clean internal components in the panel, breaker and starter.
- Check and tighten all connections of cable, wires, jumpers and bus-bars. All carbon deposits shall be cleaned.
- Check relay setting.

4.13.3 Quarterly

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

4*.13.4 Yearly*

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

History register showing repairs, replacement etc in LT Panels, starters etcwill be recorded

CAPACITORS

4.14.1 Pre-requisites for satisfactory Functioning of Capacitors

Ensure following points:

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

ii) Cable lugs of appropriate size should be used.

iii) Two spanners should be used to tighten or loosen capacitor terminals. The lower nut should be held by one spanner and the upper nut should be held by the another spanner to avoid damage to or breakage of terminal bushings and leakage of oil.

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

v) The capacitor should always be earthed appropriately at the earthing terminal to avoid accidental leakage of the charge.

vi) There should be a clearance of at least 75 mm on all sides for every capacitor unit to enable cooler running and maximum thermal stability. Ensure good ventilation and avoid proximity to any heat source.

vii) While making a bank, the bus bar connecting the capacitors should never be mounted directly on the capacitor terminals. It should be indirectly connected through flexible leads so that the capacitor bushings do not get unduly stressed.

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

4.14.2 Operation and Maintenance of Capacitors

i) The supply voltage at the capacitor bus should always be near about the rated voltage. The fluctuations should not exceed + 10% of the rated voltage of the capacitor.

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

iii) The discharge resistance efficiency should be assessed periodically by sensing, if shorting is required to discharge the capacitor even after one minute of switching off.
If the discharge resistance fails to bring down the voltage to 50V in one minute, it needs to be replaced.

iv) Leakage or breakage should be rectified immediately. Care should be taken that no appreciable Quantity of impregnate has leaked out.

v) Before physically handling the capacitor, the capacitor terminals shall be shorted one minute after disconnection from the supply to ensure total discharging of the capacitor.

vi) Replace capacitor if bulging is observed.

4.16 Maintenance of D.C. Batteries

Maintenance schedule as under shall be applicable for D.C. Batteries.

4.16.1 Daily:

- Check voltage and specific gravity of the batteries and battery supply for the tripping circuit.

4.16.2 Weekly:

- Check the battery charging & fuses and clean contact faces.

4.16.3 Monthly:

- Apply petroleum jelly or grease to battery terminals.

4.16.4 Quarterly:

- Check to ensure that battery is not overcharged/under charged.

4.16.5 Yearly:

- Check rectifier, diode, rheostat motor thoroughly.

4.17 Maintenance of lifting equipments

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

4.17.1 Quarterly:

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

4.17.2 Half-yearly:

- Clean limit switches.
- Clean all electrical contacts.

4.17.3 Yearly:

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

4.18 MAINTENANCE OF PUMPING STATIONS

Maintenance as follows shall be carried out for penstock gate, sump, suction well and pump house including civil works.

4.18.1 PENSTOCK/ GATE VALVE

i) ***Monthly :***

- The penstock/sluice gate normally remains in open position and closed only when inflow is to be stopped. Since floating matters may adhere to the gate and may accumulate in the seat, it should be operated once in a month. In order to ensure that gate remains free for operation

ii) ***Yearly :***

- The gate should be thoroughly inspected once in a year preferably after monsoon and components found worn out shall be replaced. Particular attention shall be paid to the seats of the frame and gate.

- The gate should be closed to check the leakages. For this purpose, the sump/intake shall be partly dewatered so that differential head is created on the gate and leakage test at site can be performed.

4.18.2 CLEAR WATERSUMP AND SUCTION WELL

- Allforeign floating matters in the sump shall be manually removed at least once in 3 month and shall be disposed off away from pump house.
- There is every likelihood of deposit of very fine and silt particles over the floor, corners of rectangular/square sumps and far end of suction/foot valve of pump set. This deposit shall be removed when opportunity is available. Sometimes the sludge like deposit will deteriorate the quality of water pumped necessitating urgent cleaning works

4.18.3 PUMP HOUSE

- The pump house should be cleaned daily. Good housekeeping and cleanliness are necessary for pleasant environment.
- Entire pump house, superstructure and sub-structure shall be adequately illuminated and well ventilated. Poor lighting, stale air etc. create unpleasant environment and have an adverse effect on will

  of the staff to work.
- It is observed that at many places, roof leaks badly and at times the leakage water drips on the Isolators / panels /starters/motors which is dangerous and can cause short circuit and electric accidents.

  All such leakages should be rectified on priority.
- All facilities in sub-structure i.e. stair case, floors, walkways etc. should be cleaned daily.
- Painting of civil works should be carried out at least once 5 years.

History register for replacement to light fittings will be recorded in Form-7

History Register for civil repair and maintenance works done in sumps, pump houses, MBR etc will be recorded in Form-8

History Register for mechanical repairs and maintenance works on pipe connections and valves, ladders,

in sumps, pump houses, MBR etc will be recorded in Form-9

4.19 PREDICTIVE MAINTENANCE

Predictive maintenance is the term used to examine and predict likely failure of components. As this requires experience, anticipation, good judgment and expertise and involves costs for repairs for predicted failures, it can be adopted at important, vital and large pumping stations. Some factual evidence i.e. declining of pump performance, excessive noise or bearing temperature, increase of vibration can indicate that the pump probably needs to be overhauled or bearing need to be replaced. Efforts should be made to rectify noise and vibration level by critical study and adopting measures for

rectifications. If noise or vibration still persists, the pump should be dismantled and thoroughly checked. If significant reduction in discharge is suspected, performance test at site shall be conducted with calibrated instruments and the results of the tests are compared with initial results of new pump. After fully ascertaining that the performance has considerably declined, decision to overhaul may be taken. In some installations particularly if raw water is corrosive or contains grit or sand, the pump may become prematurely due for overhaul due to deterioration caused by corrosion or erosion.

In such cases, the decision for overhaul should be based on circumstantial evidence i.e. previous history. As a long term solution, the manufacturer should be consulted for use of better material of construction for affected components.

FACILITIES FOR MAINTENANCE AND REPAIR

Facilities as follows should be provided for maintenance, inspection and repairs in the pumping installation.

- Adequate stock of consumables and lubricants
- Adequate stock of spare parts
- Tools and testing instruments
- Lifting equipment
- Ventilated and illuminated adequate space for repairs

4.22 CONSUMABLES AND LUBRICANTS

Adequate stock of gland packing, belts, gaskets, lubricating oil, greases, transformer oil, insulation tape, sealing compound, emery paste etc. shall be maintained. The consumables and lubricants shall be of proper quality and grade. Quantity shall be decided depending on consumption and period required to procure and replenish the stock.

4.23 SPARE PARTS

Adequate stock of spare parts should be maintained to avoid downtime due to non-availability of spares.

4.24 TOOLS

Each pumping installation with HT Motors should be equipped with all necessary tools, testing instruments and special tools required for repairs and testing. Their quantity and special tools depend on size and importance of installation.

All smaller pumping stations with Opedn Well Submersible Pumps shall have electrical line tester and one screw driver.

4.25 LIFTING AND MATERIAL HANDLING AIDS

Following lifting and material handling aids shall be kept in the pump house.

- Chains
- Wire rope
- Coir/ Manila rope
- Chain pulley block and tripod.
- Ladder

4.26 TROUBLE SHOOTING OF PUMPS, MOTORS AND OTHER INSTALLATIONS

"TROUBLESHOOTING" information is intended to guide in the general determination of problems in the pumping machinery and similar installations and their solutions. Technically qualified personnel should install pumps and motors. It is most essential that a licensed contractor shall install all new systems and replace existing pumps and motors. Failure to install in compliance with codes/ manufacturers recommendations may result in electrical shock, fire hazard, unsatisfactory performance, and equipment failure.

Trouble shooting check charts for the following equipments are enlisted below.

- Pumps (Submersible, Centrifugal, VT, vacuum, jet, reciprocating).
- Electric motor
- Capacitors
- Starters, breakers and control circuits
- Panels
- Cables
- Transformer
- Batteries
- Air compressor

WARNING: Unplug pump from power source before handling. Failure to do so could result in severe personal injury or death when touching the pump or discharge piping.

4.26.1 Submersible Well Pump Troubleshooting

Trouble	Cause	Remedy
Motor Does Not Start	No power or incorrect voltage	Check voltage at line terminals. The voltage must be ± 10% of rated voltage. Contact Power Company if voltage is incorrect.
	Fuses blown or circuit breakers tripped	Check fuses for recommended size and check for loose, dirty or corroded connections in fuse receptacle. Check for tripped circuit breakers. Replace with proper fuse or reset circuit breakers
	Defective pressure switch:	Check voltage at contact points. Improper contact of switch points can cause voltage less than line voltage. Replace pressure switch or clean points
	Control box malfunction	Repair or replace
	Defective wiring Check for loose or corroded connections or defective wiring	Correct faulty wiring or connections
	Bound pump	Check for misalignment between pump and motor or a sand bound pump. Amp readings will be 3 to 6 times higher than normal until the overload trips.

		Pull pump and correct problem. Run new installation until the water clears.
	Defective cable or motor	Repair or replace
Motor Starts Too Often	Pressure switch:	Check setting on pressure switch and examine for defects. Reset limit or replace switch.
	Check valve - stuck open	Damaged or defective check valve will not hold pressure. Replace if defective.
	Leak in system	Check system for leaks. Replace damaged pipes or repair leaks
.Motor Runs Continuously	Pressure switch	Check switch for welded contacts. Check switches adjustments. Clean contacts, replace switch, or adjust setting.
	Low water level in well	Pump may exceed well capacity. Shut off pump, wait for well to recover. Check static and drawdown level from well head. Throttle pump output or reset pump to lower level. Do not lower if sand may clog pump.
	Leak in system:	Check system for leaks. Replace damaged pipes or repair leaks.
	Worn pump	Symptoms of worn pump are similar to those of drop pipe leak or low water level in well. Reduce pressure switch setting, if pump shuts off worn parts may be the fault. Pull pump and replace worn parts.
	Loose coupling or broken motor shaft	Check for loose coupling or damaged shaft. Replace worn or damaged parts.
	Pump screen blocked:	Check for clogged intake screen. Clean screen and reset pump depth.
	Check valve stuck closed	Check operation of check valve. Replace if defective
	Control box malfunction	Repair or replace
Motor Runs But Overload Protector Trips	Incorrect voltage:	Using voltmeter, check the line terminals: Voltage must be within ± 10% of rated voltage. Contact Power Company if voltage is incorrect.
	Overheated protectors	Direct sunlight or other heat source can raise control box temperature causing protectors to trip. The box must not be hot to touch. Shade box, provide ventilation or move box away from source.

	Overheated protectors	Direct sunlight or other heat source can raise control box temperature causing protectors to trip. The box must not be hot to touch. Shade box, provide ventilation or move box away from source.
	Defective control box	Repair or replace.
	Worn pump or motor:	Check running current. Replace pump/ motor/cable.
Little Or No Liquid Delivered By Pump	Faulty or incorrectly installed check valve:	Inspect check valve and repair as required.
	Pump air Bound	Successively start and stop pump until flow is delivered.
	Pump not fully submerged	Check well recovery, lower pump if possible.
	Excessive pump wear	Pull pump and repair or replace as required.

4.26.2 TROUBLE SHOOTING FOR CENTRIFUGAL PUMPS

Problem	Causes	Remedial action
Low flow/low pressure	Pump is not primed	Repeat priming procedure.
	Rotation speed is not adequate	Increase the motor speed in relation to the working conditions. If the problem still persists, explore replacing impeller with larger diameter
	Wrong direction of rotation	Inter change connections of two leads at motor or at switch board for proper phases
	Air pockets in suction line	Check all pipe joints on suction piping, submergence of foot valve,
	Air enters suction line	Check piping sealing and pipe joints
	Suction pressure is more than the designed suction pressure	Increase suction pipe length suitably
	Excessive wear in impeller/ impeller neck/diffusers	Overhaul pump and replace parts ,if necessary
	Suction piping is not submerged in water causing vortex	Increase submergence of foot valve (Open end of suction pipe in case of positive suction)
	Scale formation in Impeller and entry of solids	Take out Impeller and clean scaling and fine deposits on vane and remove the foreign materials
	Piping plugged	• Check NRV valve • Clean piping, Butterfly valve stem
Excessive flow/ High pressure	Actual pressure required is lower than design head	• Adjust flow regulating valve on delivery side • Decrease impeller diameter

Power consumption is high	Actual pressure required is lower than design head	Adjust flow regulating valve on delivery side Decrease impeller diameter
	Pump-Motor coupling is mis-aligned.	Re-align the coupling
	Bearings are worn-out	Replace bearing
Excessive vibration and noise	Suction pressure is more than the designed suction pressure	Increase suction pipe length suitably
	Pump-Motor coupling is mis-aligned.	Re-align the coupling
	Pump/piping is loose	Tighten the bolts as required
	Impeller is out of balance due to wear/fine solid deposit/encrustation	Overhaul the pump
	Forces, moments, and piping mis-alignment are loading the pump.	*Re-align and supports of piping*
	Impeller is out of balance due to wear/fine solid deposit/encrustation	Overhaul the pump
Bearing over heating	Pump-Motor coupling is mis-aligned.	Re-align the coupling
	Bearings are worn-out	Replace bearing
	Forces, moments, and piping mis-alignment are loading the pump.	*Re-align and supports of piping*
	Poor quality oil, low oil level in bearing house and lack of grease	*Replace oil/grease of good quality to required level.*
	Power consumption is high	*Decrease power consumption by identifying causes*
	Pump is running dry	*Reinstate correct working conditions*
	There is water in the bearing frame	Change bearings and all the contaminated lubricant.
Bearing Malfunctioning	Forces, moments, and piping mis-alignment are loading the pump.	*Re-align and supports of piping*
	Pump is running dry	*Reinstate correct working conditions*
	Shaft sleeve is worn out	Replace with new shaft sleeve
	Too much grease in the bearing.	Remove excess grease
	Mechanical seals are damaged	Overhaul and change mechanical seals

4.26.3 TROUBLE SHOOTING FOR DELIVERY PIPES, HEADER AND NRV

Sl. No	Trouble	Cause	Remedy
1.	Undue thrust on pump foundation and bend in delivery pipe causing shearing or uprooting of foundation bolts of pumps and	Dismantling joint is not properly designed, to counter thrust at the elbow in	Provide dismantling joint of proper design. The design should ensure that it has long tie-bolts connecting rigid flanges and thus

	thrust on common header.	the pump.	taking up the pull caused by thrust at pump.
2	Cracks in welded jointed of individual delivery and common header.	The cracks are caused due to thrust at dead end of common header	Provide thrust blocks at dead (free) end of common header.
3	Reflux valve (NRV) closes with slam and high noise in the event of shut-down or power failure or tripping.	The reflux valve is not designed for non-slam in closure.	• Replace with reflux valve designed for non-slam closure. • Taken up issue of old valve to valve manufacturer

4.26.4 TROUBLE SHOOTING FOR ELECTRIC MOTOR

Sl. No	Trouble	Cause	Remedy
1	Hot bearings	Bent or sprung shaft	Straighten or replace shaft.
		Excessive belt pull.	Decrease belt tension
		Misalignment	Correct coupling alignment.
		Bent or damaged oil rings.	Replace or repair oil rings
		Oil too heavy or too light	.Use recommended oil. Use of oil of too light grade is likely to cause the bearings to seize.
		Insufficient oil level	Fill reservoir to proper level when motor is at rest.
		Badly worn bearings	Replace bearings.
		Bearing loose on shaft or in bearing housing.	Re-metal shaft/housing or bearing housing replace shaft or housing.
		Insufficient grease	Maintain proper quantity of grease in bearing.
		Deterioration of grease or lubricant contaminated	Remove old grease, wash bearings thoroughly with kerosene and replace with new grease.
		Excessive lubricant	Reduce quantity of grease. Bearing should not be more than two-third filled.
		Overloaded bearing	Check alignment, side thrust and end thrust.
		Broken ball or rough races.	Clean housing thoroughly and replace bearing.

2.	Motor dirty	Ventilation passage blocked. Windings coated with fine dust or lint parts (dust may be cement, sawdust, rock dust, grain dust and the like).	Dismantle entire motor and clean all windings and by blowing off dust, and if necessary, varnish,
		Bearing and brackets coated inside	.Clean and wash with cleaning solvent
		Rotor winding coated with fine dust/cement	• Clean and polish slip ring. • Clean rotor and varnish

Sl. No	Trouble	Cause	Remedy
3.	Motor stalls	Motor overloaded	Check any excessive rubbing or clogging in pump
		Low voltage	Correct voltage to rated value.
		Open circuit	Fuses blown, check overload relay, starter and push button.
		Incorrect control resistance of wound motor	• Check correct sequence; • Replace broken resistors.
		• Mechanical locking in bearings or at air gap	• Dismantle and check bearings. • Clean if any foreign matter has entered air gap
4	Motor does not start	No supply voltage or single phasing or voltage too low.	• Check voltage in each phase.
		Motor may be overloaded	Start on no load by decoupling. Check for cause for overloading.
		Starter or switch/ breaker contacts improper	Examine starter and switch/breaker for bad contact or open circuit.
		Initial starting torque of load too high.	• If of squirrel cage type and with auto-transformer starter, change to a higher tap. • If of slip ring type, lower the starting resistance.
		Rotor defective	Check for broken rings.
		Poor stator coil connection	Remove end shields, check end connections
		Mechanical locking in bearings or at air gap	Dismantle and repair. Clean air gap if choked.

5	Motor runs and then stops	Power supply system faulty	Check for loose connections or single phasing in switches/ breakers / starter / bus-bars.
		Overload replay trips.	Examine overload relay setting. Ensure that the relay is set correctly to about 140-150% of load current.
			Check whether dashpot is filled with correct quantity and grade of oil.
6.	Motor does not accelerate	Voltage too low at motor terminals because of line drop.	• Check voltage • Change tapping on transformer, if required
		Improper connection	Check secondary connections
7.	Motor takes too long to accelerate	Excess loading	Reduce load. (Note that if motor is driving a heavy load or is starting up a long line of shafting, acceleration time will be more)
		Timers setting of starter not correct.	Check whether timer setting of star – delta or autotransformer starter is less than acceleration time required for the torque of driven equipment.
		Applied voltage too low	• Correct the voltage by changing tap on transformer. • It voltage is still low, take up the matter to TNEB
8.	Wrong rotation	Wrong sequence of phases	Inter change connections of two leads at motor or at switch board for two phases.
9.	Motor overheats while running	Check for overload	• Check for pipeline burst • Pump may operate at low head • Vortices in sump may also cause overload
		Motor may have one phase	Make sure that all leads are well connected
		Unbalanced terminal voltage	Check for faulty leads, connections right from transformer
		High or low voltage	Check voltage of motor and correct it to the extent possible.
10.	Motor vibrates after connections have been made	Motor misaligned	Re-align
		Weak foundations or holding	Strengthen base plate/ down bolts loose foundation; tighten holding down bolts

		Coupling out of balance	Balance coupling
		Defective bearings	Replace bearing
		Bearings not in line	Line up properly
		Single phasing	Check for open circuit in all phases
		Resonance from supporting structure or foundation or vibration of adjoining equipment	Consult with expert
11.	Unbalanced line current during normal operation	Unbalanced terminal voltage	Check leads and connections
		Single phase operation	Check for open contacts or circuit in all phases.
12.	Scraping noise	Fan rubbing air shield or striking insulation.	Check for cause and rectify.
		Loose on bed plate	Tighten holding down bolts
15.	Leakage of oil or grease	Excessive oil, grease in bearing.	• Fill correct quantity of oil • Grease should be filled upto maximum half space in bearing housing

4.26.5 TROUBLE SHOOTING FOR CAPACITORS

Sl. No.	Problem	Causes	Remedial action
1.	Leakage of heclor*	• Leaking welds & solders	Repair by soldering
		Broken insulators	Replace insulators.
2.	Overheating of unit	Poor ventilation	Arrange for circulation of air either by reinstalling in a cooler and ventilated place or arrange for proper ventilation.
		Over voltage	Reduce voltage if possible, otherwise switch off capacitors
3.	Current below normal value	Low voltage	Correct the voltage.
		Element fuses blown	Replace fuses
		Loose connections	Tighten carefully
4.	Abnormal bulging	• Gas formation due to internal arcing	Replace the capacitor
5.	Cracking sound	Partial internal faults.	Replace the capacitor

6.	HRC Fuse blowing	Short circuiting	Check and attend short circuting
		Over-current due to over voltage and harmonics	Reduce voltage and eliminate harmonics.
		Short circuited unit	Replace the capacitor.
		kVAR rating higher.	Replace with bank of appropriate kVAR.
7.	Capacitor not discharging	Discharge resistance low	Correct or replace the discharge resistance
8.	Unbalanced current	Insulation or dielectric failure	Replace capacitor unit.

*Leakage of Heclor from terminals, insulators or lid etc. is not a serious trouble. After cleaning, the nuts should be tightened carefully, araldite shall be applied if necessary and the capacitor should be put into circuit. If the leakage still continues, refer the matter to manufacturer.

4.26.6 TROUBLE SHOOTING FOR STARTERS, BREAKERS AND CONTROL CIRCUITS

Sl. No.	Problem	Causes	Remedial action
1.	Starter/breaker not switching on	Non availability of power supply to the starter/ breaker	Check the supply
		Over current relay operated	Reset the relay
		Relay reset not operating	Clean and reset relay
		Castle lock is not locked properly	Remove lock and lock it properly
2.	Starter/breaker not holding on ON-Position	Relay contacts are not contacting properly	Check and clean the contacts
		Latch or cam worn out	Readjust latch and cam.
3.	Starter/breaker tripping within short duration due to operation of over current relay	Over current relay setting incorrect.	Check and reset to 140-150% of normal load current.
		Moderate short circuit on outgoing side	Check and remove cause for short circuit.
		No or less oil in dashpot	Fill oil upto level mark.
		Dashpot oil not of proper grade.	Check and use oil of correct grade.
		Sustained overload	Check over current setting.
			Check for short circuit or earth fault.
			Examine cause of overload and rectify.
		Loose connection	Clean arc deposits and tighten.
4.	Starter/breaker not tripping after over-current or short circuit fault occurs	Lack of lubrication to mechanism	Lubricate hinge pins and mechanisms.
		Mechanism out of adjustment	Adjust all mechanical devices Like toggle stops, buffers, springs as per manufacturer's instructions.

		Failure of latching device	Examine surface, clean and adjust latch. If worn or corroded, replace it.
		Relay previously damaged by short circuit	Replace over-current relay and heater.
		Heater assembled incorrectly	Review installation instructions and correctly install the heater assembly
		Relay not operating due to:	
		Blown fuse	Replace fuse.
		Loose or broken wire	Repair faulty wiring; ensure that all screws are tight.
		* Relay contacts damaged or dirty	Replace damaged contacts
		Damaged trip coil	Replace coil.
		C.T. damaged	Check and repair/replace , if necessary.
5.	Overheating	Poor condition of contacts	Clean and polish contacts
		Contacts out of proper alignment	Align the contacts.
		Contacts burnt or pitted	Clean the contacts with smooth polish paper or if badly burnt/pitted, replace contacts. (contacts shall be cleaned with smooth polish paper to preserve faces. File should not be used.)
		Loose power connection.	Tighten the connection
		Sustained over-current	Check cause and rectify for short circuit/earth fault.
		Poor ventilation at location	Improve ventilation of starter/breaker.
6.	Overheating of auto transformer unit	Winding design improper	Rewind.
		Transformer oil condition poor	• Replace transformer oil in auto-transformer unit.
7.	Contacts chatter	Low voltage	Check voltage condition. Check momentary voltage dip during starting. Low voltage prevents magnet sealing. Check coil voltage rating.
		Poor contact in control circuit	• Check push button station,(stop button

			contacts), auxiliary switch contacts and overload relay contacts and test with test lamp. • Check for loose connections in control circuits.
		Defective or incorrect coil.	Replace coil. Rating should compatible for system nominal voltage.
8.	Contacts welding	Abnormal inrush of current	Check for grounds & shorts in system as well as other components such as circuit breaker.
		Low voltage preventing magnet from sealing	Check and correct voltage.
		Short circuit	Remove short circuit fault and ensure that fuse or circuit breaker rating is correct
9.	Short push button and/ or over heating of contacts	Filing or dressing	Do not file silver tips. Rough spots or discolouration will not harm tips or impair their efficiency.
		Interrupting excessively	Check for short circuit, earth high current fault or excessive motor current.
		Discoloured contacts caused by insufficient contact pressure, loose connections etc	Replace contact springs, check contact for deformation or damage. Clean and tighten connections
		Dirt or foreign matter on contact surface	Clean with carbon tetrachloride
		Short circuit.	Remove fault & check fuse or breaker rating whether correct.
10.	Coil open circuit	Mechanical damage	Examine and replace carefully. Do not handle coil by the leads.
		Burnt out coil due to over voltage or defect.	Replace coil.
11.	Magnets & other mechanical parts worn out/broken	Too much cycling	Replace part and correct the cause of damage.
		Dust and dirt or mechanical abuse.	
12.	Noisy magnet (humming)	Defective coil	Replace coil
		Magnet faces not mating correctly	Replace magnet assembly. Hum may be reduced by removing magnet armature and rotating through 180o.

		Dirt oil or foreign matter on magnet faces	Clean magnet faces with . carbon tetrachloride.
		• Low voltage	Check system voltage and voltage dips during starting.
13.	Failure to pick-up and/ or seal	Low voltage	Check system voltage and voltage dips during starting.
		Coil open or shorted.	Replace coil.
		Wrong coil.	Check coil voltage rating which must include system nominal voltage and frequency.
		Mechanical obstruction	• With power off, check for free movement of contact and armature assembly. • Remove foreign objects or replace contactor.
		Poor contact in control circuit.	Check and correct.
14.	Failure to drop out	Gummy substances on pole faces or in mechanism	Clean with carbon. tetrachloride.
		Voltage not removed from control circuit.	Check control circuit
		Worn or rusted parts causing binding (e.g.) coil guides, linkages	Replace contactor.
		Improper mounting of starter	Check installation and mount properly
15	Failure to reset	Broken mechanism , worn out parts, dirt, corrosion etc.	Replace over current relay, space heater et

4.26.7 TROUBLIE SHOOTING FOR PANELS

Sl. No.	Problem	Causes	Remedial action
1	Overheating	Bus bar capacity inadequate	Check and provide additional bars in combination with existing bus-bars or replace bus-bars.
		Loose connection	Tighten the connection
		Improper ventilation	Improve ventilation
2	Insulator cracked		Replace the insulator

4.26.8 TROUBLIE SHOOTING FOR CABLES

Sl.No.	Problem	Causes	Remedial action
1.	Overheating	Cable size inadequate	•Provide a cable in parallel to existing cable or higher size cable • Increase clearance between cable
2	Insulation burning	Improper termination in lug termination	• Check size of lug and whether properly crimpled •Check whether only few strands of cable are inserted in lug. Insert all strands using a new or higher size lug if necessary.

5.0 CHLORINATION AND CHLORINATORS

5.1 Introduction

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

In our case, we are receiving treated water with residual chlorine from Package-1. Hence the application is only *re-chlorination*

5.2 Objectives of the re-chlorination

The primary objective of the re-chlorination process is improving further residual chlorine for further transmission to consumers.

5.3 Use of Chlorinators

The conventional re-chlorination facility i.e. adding chlorine for disinfection of water consists of three essential parts:

1. Chlorine supply system
2. Metering system
3. Diffuser system

In addition to above, there are ancillary equipment, safety equipment, metering & control instrumentation and chlorine residual analyzers.

5.3.1 CHLORINE GAS SUPPLY SYSTEM

a) Chlorine Gas Supply System

In gas supply system if the header run passes through an area where ambient temperature may fall below the temperature of the gas leaving the supply containers, it is necessary to install a pressure reducing valve in the gas supply system. This valve prevents re-liquefaction of the gas downstream of it. It is also a good practice to install liquid chemical trap upstream of the valve. The trap will serve to prevent liquid chemical from entering and flashing across the valve seat resulting in poor pressure regulation.

b) Evaporator Supply System or Liquid Chlorine Supply System

By means of an evaporator, liquid chlorine is converted into gaseous form. Chlorinator operates the evaporator as per its requirement of chlorine. If requirement of chlorine gets reduced, pressure in the evaporator increases causing liquid chlorine level in it to reduce, thereby reducing its area, which in turn reduces heat transfer.

On the contrary, if requirement of chlorine increases, the pressure in the evaporator decreases. As a result of it more liquid is pushed into the evaporator where it is evaporated at higher rate.

c) Chlorine Gas Filter

Small chlorinators usually have same sort of built-in chlorine filter. Commonly used material for this purpose is glass wool.

d) External Chlorine Pressure Reducing Valve

Any installation using the variable vacuum system for automatic control requires such a valve to reduce the chlorine supply pressure to 2 to 2.75 kg/cm2 ahead of the chlorinator to ensure the maximum possible accuracy of the control system. Secondly, this valve also reduces the pressure in the chlorine supply header to prevent re-liquefaction of the gas in the header between the last cylinder connected and the chlorinator

5.3.2 Metering system in Chlorinator

A chlorinator is a device for feeding chlorine to a water supply. It also serves as gas metering device. Chlorinators are classified into two categories.

- Pressure type
- Vacuum type

In our case, our installation is Vacuum type and hence discussion is limited to Vacuum Chlorinator.

5.4 Vacuum type Chlorinator

In this type of chlorinator, chlorine is handled below the atmospheric pressure. The vacuum system has several advantages:

- It is the easiest method of dissolving chlorine in water.
- Chlorine is easily handled when in solution.
- This is the most accurate way of metering chlorine gas since a constant density is maintained under vacuum and it is not affected by ambient temperature changes.
- Operation under vacuum is safer than operating under pressure.
- A metering system can be easily designed to stop automatically if the vacuum should fail. It consists of a gas filter, pressure regulating valve, variable area flow meter (Rotameter), vacuum regulating valve, pressure vacuum relief valve, drain valve and injector assembly.

If the system is designed for chlorine gas withdrawal, the following procedure for starting up the system is adopted.

5.4.1 Start up of Gas Chlorine System

1. First start the booster pumps and make certain that the hydraulic conditions are satisfactory. For that purpose see the delivery water pressure & injector vacuum gauge reading. If the conditions are satisfactory, the vacuum gauge should show reading above 590 mm of Hg. If the chlorinator is not equipped with vacuum gauge, remove the tubing at the injector vacuum inlet and place a hand over the opening. If the injector is performing properly, the suction will be felt instantly on the portion of the hand over the opening. But it is advisable to have a vacuum gauge for proper operation of the plant with safety.
2. Check that all the chlorine valves on the supply line to chlorinators are closed.
3. When the injector system is functioning properly, open the valve of chlorine cylinder partially to allow the gas. Chlorine container should be connected to the system and kept ready before starting the plant.
4. Verify that all of the tubing, manifold and auxiliary valve connections are correct and that all union

joints are properly gasketed. Check the leakage with ammonia stick and if there is any leakage, closethecylinder valve immediately and attend to the leaking joint to make it leak proof.

5. Check all the joints between cylinder valve to end.

6. Open the chlorine valve slightly to injector and check all the tubing and components of chlorinators for leakage. Attend if necessary by closing inlet valve. If there is no leak, then the chlorinator is ready for further testing.

7. Open fully the chlorinator gas inlet valve and check the chlorinator for range, automatic control and so on.

8. If at any stage leakage of chlorine is found, close the cylinder valve. Allow the gas in the system to be consumed through injector and then attend for leaking joints.

9. If the leakage is due to missing gaskets etc., close the cylinder valve. Leave the site immediately for safe area. With the help of breathing apparatus carry out the gas evacuation procedure through the chlorinators.

10. After all leaks have been corrected the next step will be to see that the chlorinator will reach its maximum capacity as specified. This is the most important operative criteria of the chlorinator installation.

11. If the chlorinator is not giving specified dose check for injector vacuum and chlorine pressure in the system and attend to the defects. The fault is normally in the hydraulics of the injector system. The next likely place is within chlorinator itself.

A malfunction in either place is reflected by a low vacuum reading on the injector vacuum gauge.

i) The first step in this case is to check the vacuum leak within the chlorinators. If the leak is major, it can be discovered by shutting off the injector water suddenly and using ammonia on all the joints. This sudden removal of vacuum will create slight pressure and chlorine will be expelled into atmosphere. Very small leak will not show up in this procedure.

ii) Then check for 'O' ring seal in metering tube, vacuum relief valve, for defective spring or seat etc. and attend to it.

12. Vacuum will be affected due to long vacuum line between injector and chlorinator. If this is filled with air, the large amount of air reduces injector vacuum. Moreover if this line is leaking it will also reduce the vacuum. Like a long vacuum line, a long chlorine solution line will also affect the injector vacuum. The air in this line, therefore needs to be removed.

13. Defective injector may also affect vacuum.

5.4.2 Start up of Liquid Chlorine System

If the system is designed for liquid withdrawal, the following procedure should be adopted for starting it up.

The procedure for start up on a liquid system is similar to gas system except for the role of evaporator. The evaporator is an extension of chlorine container system. Whatever happens in the container reflects into the evaporator pressure changes. The danger existing in liquid system is the possibility of trapping liquid chlorine in a pipe line. If this occurs and there is a significant rise in the ambient temperature, the

liquid chlorine will expand & rupture the pipe line. For this reason, the liquid line between the evaporator & chlorine supply system should always remain open while the evaporator is operating. From safety point of view, rupture disc system with expansion chamber is provided on this line.

The first step preparatory for starting up a liquid system is to verify that the system is dry, because the moisture after coming in contact with liquid chlorine & metal of container forms ferric chloride which will pass through the chlorine control mechanism with stoppage of chlorine. Whenever this occurs the entire chlorine system must be flushed with water & thoroughly dried. In addition to this, chlorination equipments must be dismantled and cleaned.

When the operator is convinced that the chlorine supply system is clean & dry, the next step is to start up the evaporators. This is done by filling the water bath and adjusting the control devices. When the water bath reaches 65^{o}C temperature, the chlorine pressure reducing valve & shut off valve will open and the system is ready for operation. When water temperature reaches 82oC, start the injector water system and follow the procedure mentioned in gas system.

5.4.3 Procedure for Stopping the chlorination system

Stopping the chlorination system is also important in order to avoid chlorine leakages as well as for the system safety. The procedure is as follows:

1. Shut off the chlorine supply system.
2. When the chlorine pressure gauge reaches zero remove the cylinder connection & allow the air to evacuate all the residual chlorine gas in the system while the injector is still in operating condition.
3. After the chlorine has been purged to the satisfaction of the operator, the injector system may be shut down.
4. Connect the openings with plastic plugs.
5. For liquid system the chlorine in the evaporator shall be completely consumed.
6. Then close the heater supply to the evaporator.

5.4.5 Maintenance of chlorination Equipment

Chlorine being hazardous chemical, its operating machinery should be maintained properly.

In view of this, it is advisable to carry out preventive maintenance of all these equipment keeping in mind the followings for effective maintenance management programme.

(**a**) 1. Deploy trained personnel

2. Prepare daily schedule i.e.
   - Check chlorine leakage by ammonia torch.
   - Check exhaust fans working.
   - Check rotameter functioning.
   - Carry out physical verification of stock and position of tonners.
   - Check position of safety equipment.
   - Check vacuum of chlorinator.
3. Quantify the work.

4. Use of work permit system. A written work permit system is essentially a document which Identifies the plant to be worked on and details precautions to be taken before a work can start. It Predetermines the safe procedure and is a clear record of the hazards that have been anticipateddefining the appropriate precautions to be taken to avoid them. It is also a statutory requirement.
5. Keep equipment record i.e. history cards.
6. Analyse and plan every job.
7. Forecast yearly & monthly maintenance programme.
8. Prepare check lists for different types of preventive maintenance.
9. Set up a manpower control.
10. Set up a preventive maintenance programme.
11. Use budgetary control – yearly & monthly budget.
12. Provide material control.
13. Always use recommended spares.
14. Plan plant shut downs.
15. Establish major overhaul procedures.
16. Develop standard practices.
17. Improve efficiency of the equipments.
18. Train the supervisors.
19. Train the maintenance staff.
20. Analyse performance and cost.

(**b**) Since the properties of Chlorine differ in liquid form, gaseous form, and solution form suitable material has to be selected for various components of chlorine equipment.

(c) Predominantly observed impurities in chlorine are Ferric chloride, Hexachlorethane and Hexachlorbenzene. Normally the chlorine available for disinfection purpose is 99.8% pure (IS 646).

(d) Ferric chloride is formed due to reaction of chlorine with water vapour & metal. This is deposited in the equipment during corrosion from liquid form to gaseous form. While carrying out maintenance of this equipment, warm water is used to clean the equipment. The cleaned equipment is dried thoroughly before putting into the system.

(e) Hexachlorethane & Hexachlorbenzene being volatile impurities, are deposited from the chlorine gas in the equipment wherever pressure changes occur in the system, for example with pressure reducing valve. These impurities are removed while carrying out maintenance by means of trichloroethane or Isopropyl alcohol, Carbon Tetra Chloride (CTC) should never be used as it is carcinogenic.

(f) Sometimes amongst other impurities, nitrogen trichloride may be present. This impurity is present when the brine solution from which chlorine is manufactured by electrolysis method, containsammonia or its compound. Because of vapour pressure difference in nitrogen trichloride and chlorine in the evaporator, chlorine is evaporated first leaving more concentration of nitrogen trichloride in Evaporator. If under such condition, the evaporator temperature exceeds 94^0C, the evaporator may explode. It is, therefore, always recommended not to exceed evaporator temperature of 90 ^{0}C.

(g) Before carrying out any maintenance of the equipment, it should be confirmed that all the chlorine present in equipment is purged out completely. Any chlorine present in the piping will prove hazardous if welding work is carried out on it. Similarly while putting the chlorination system into use all the water vapours should be removed by means of moisture free dry air. The piping carrying chlorine of a length more than 3 mtrs. Running from cylinder to the equipment should be provided with a pressure reducing valve just down stream of the cylinder. These two aspects reduce the maintenance problems to a minimum. Whenever cylinders are removed from the system, the disconnected piping should be plugged with Teflon or similar kind of material in order to avoid entry of humid air into it.

History register showing repairs, replacement on Chlorination equipments will be recorded in Form-11

5.5 Safety aspects of Chlorine

5.5.1 General

Chlorine is potentially dangerous. It is, therefore, important that person engaged in a chlorine plant or in any activity involving handling of chlorine should understand the hazards of chlorine and should know preventive measures needed. These are given below:

5.5.2 *Important Facts about Chlorine from Safety point of View*

- Chlorine is supplied in liquid form under pr5essure.and it requires heat for converting into gas.
- It is not poisonous but highly irritant.
- Dry gas is not corrosive but wet gas is highly corrosive.
- Liquid chlorine has large coefficient of expansion
- Vapour pressure increases with rise in temperature.
- Gas is 2.5 times heavier than air. Hence ventilating fans are provided at floor level.
- It is dangerous with ammonia gas, hydrogen, turpentine (oil), and hydro-carbon. Reactions with these are highly explosive. Powdered metals may cause fire in chlorine.
- It is slightly soluble in water but it is easily absorbed in caustic soda /hydrated lime.
- Liquid leaks 15 times more than gas.

5.5.3 Cylinders

Cylinders are fabricated as per IS: 7681.

In a vertical position with the valve at the top, chlorine in gaseous form can be drawn from the cylinder. The withdrawal rates of Cl2 at 200C are 2 kg/hr for gas for 100 kg. The withdrawal rate depends upon ambient temperature and it reduces with reduction in temperature.

5.5.4 Container Valves

The chlorine cylinder must be fitted with standard valves conforming to IS: 3224

5.5.6 Storage and Handling of chlorine cylinder

Chlorine is stored in special grade steel containers. As per IS:4379-1967, the colour of Chlorine container should be ***'golden yellow'***.

(a) Storage Area

1. Obtain storage licence from controller of explosives under Gas Cylinder Rules 1981if the quantity of containers to be stored is more than 5 Nos.
2. Storage area should be cool, dry, well ventilated, and clean of trash and protected from external heat sources.
3. Ventilation must be sufficient to prevent accumulation of vapour pockets. The exhaust should be located either near the floor or duct be provided extending to the floor. All fan switches should be outside the storage area.
4. Do not store container directly under the sun.
5. Weather cock should be installed near the storage to determine wind direction.
6. The storage building should be of non-combustible construction with at least two exits opening outside.
7. Neutralization system should be provided.
8. Continuous monitoring of chlorine leak detection equipment with alarm should be installed in the storage area.
9. The area should be free and remote from elevators, gangways or ventilating system to avoid dangerous concentration of Chlorine during leak.
10. Two portable foam type fire extinguishers should be provided in the premises.
11. Corrosive substances shall not be stored nearby which react violently with each other.
12. Unauthorized person should not be allowed to enter into the storage area.
13. The floor level of storage shed should be preferably 30 cms (at least one foot) higher from the ground level to avoid water logging.
14. Ensure that all containers are properly fitted with safety caps or hooks.

(b) Cylinder & Drum Containers

1. Store chlorine cylinders upright and secure them so that they do not fall.
2. Drum containers should be stored on their sides on rails, a few inches above the floor. They shouldnot be stacked one upon the other. They should be stored such that the valves are in vertical plane.
3. Keep enough space between containers so as to have accessibility in case of emergency.
4. Store the containers in a covered shed only. Keep them away from any source of heat as Excessive heat may increase the pressure in container which will result into burst.
5. Do not store explosives, acids, turpentine, ether, anhydrous ammonia, finely divided metals or other flammable material in the vicinity of Chlorine.
6. Do not store containers in wet and muddy areas.
7. Store filled and empty containers separately.

8. Protective covers for valves are secured even when the containers are empty, exceptduring use in the system.

9. Never use containers as a roller to move other equipment.

10. Never tamper with fusible plugs of tonners.

11. Check leakages every day by means of ammonia torch. However, it should not be touched to brass components like valves of container for safety.

12. Never carry out any welding work on the chlorine system as combustion of steel takes place at 251^0C in presence of chlorine.

13. The boxes containing emergency kit, safety applications and self contained breathing apparatus should be kept in working order in an easily approachable area.

(c) Use of Cylinders & Drum Containers in Process System

1. Use containers in the order of their receipt, as valve packing can get hardened during prolonged storage and cause gas leaks.
2. Do not use oil or lubricant on any valve of the containers.
3. Badly fitting connections should not be forced and correct tool should always be used for opening and closing valves. They should never be hammered.
4. The area should be well ventilated with frequent air changes.
5. Transport the cylinders to the process area by using crane, hoist or railings etc.
6. The drum containers should be kept in a horizontal position in such a way that the valves are in a vertical plane. The upper valve gives out gas and the lower one gives out liquid chlorine.
7. The cylinder should be kept in upright position in order to release gas from the valve.
8. Connect the containers to the system by using approved accessories.
9. Use copper flexible tube, with lead washer containing 2 to 4% antimony or bonded asbestos or teflon washer. Use yoke clamp for connecting chlorine container.
10. Never use rubber tubes, PVC tubes etc. for making connections.
11. Use the right spanner for operating the valve. Always keep the spanner on the valve spindle. Never use ill fitting spanner.
12. After making the flexible connection, check for the leakage by means of ammonia torch but it should not come in contact with a valve.
13. Keep minimum distance between the container valve and header valve so that during change-over of the container, minimum amount of gas leaks.
14. The material of construction of the adopter should be same as that of valve outlet threads.
15. The valve should not be used as a regulator for controlling the chlorine. During regulation due to high velocity of Chlorine, the valve gets damaged which in turn can cause difficulty in closing.
16. The tools and other equipment used for operating the container should be clean and free of grease, dust or grit.

17. Wear breathing apparatus while making change-over of the container from the processheader.
18. Do not heat the container to withdraw more gas at faster rate.
19. Use pressure gauge and flow measuring device to control the flow and to know the quantity of gas left in the container.
20. Use an inverted U type barometric leg or vacuum breaking arrangement for connecting the container to the process piping.
21. Withdrawal of the gas should be stopped when the gas pressure inside the container is between 0.1 to 0.5 kg/cm2 approximately.
22. If withdrawal of the gas from the container connected to the process system has to be suspended for long intervals, it should be disconnected from the system, and the valve cap and hood replaced.
23. Gas containers should be handled by trained persons only.

(d) Disconnecting Containers from Process System

1. Use breathing apparatus before disconnecting the container.
2. First close the container valve fully. After removal of chlorine the process valve should be closed.
3. Remove the flexible connection; plug the flexible connection in order to avoid entry of humid air. Replace the valve cap or hood on the container.
4. Put the tag on the empty container & bring it to storage area marked for empties.
5. Check for the leakage.

(e) Loading and Unloading of Containers

1. The handling of containers should be done under the supervision of trained and competent person.

2. It should be done carefully with a crane, hoist or slanted ramp. Do not use magnet or sharp object for lifting the containers.

3. Small cylinders should not be lifted by means of valve caps as these are not designed to carry the weight.

4. The containers should not be allowed to strike against each other or against any hard object.

5. Vehicles should be braked and isolated against any movement.

6. After loading, the containers should be secured properly with the help of wooden wedges, rope or sling ire so that they do not roll away.

7. The containers should never be dropped directly to the ground or on the tyre from the vehicle.

8. There should be no sharp projection in the vehicle.

9. Containers must have valve caps and plugs fitted properly.

10. Check containers for leakage before loading/unloading.

Log sheet on the operation of chlorinators will be maintained in every Re-Chlorination point

(f) Transportation of Container

1. The name of the chemical along with diamond pictorial sign denoting the dangerous goods should be marked on the vehicle.
2. The name of the transporter, his address and telephone number should be clearly written on the vehicle.
3. The vehicle should not be used to transport any material other than what is written on it.
4. Only trained drivers and cleaners should transport hazardous chemical
5. The driver should not transport any leaking cylinder.
6. The cylinder should not project outside the vehicle.
7. The transporter must ensure that every vehicle driver must carry "Trem Card" (Transport Emergency Card) and 'Instructions in writing booklet' and follow them.
8. Every driver must carry safety appliances with him, viz; Emergency kit, breathing apparatus etc.
9. The vehicles must be driven carefully, specially in crowded localities and on bumpy roads. Do not apply sudden brakes.
10. Check for the leakage from time to time.
11. In the case of uncontrollable leakage the vehicle should be taken to an open area where there is less population.

Movement of Chlorine Cylinders, their position will be monitored through Form-13

(g) Emergency Kit

It consists of various tools and appliances like gaskets, yokes, studs, tie rods hoods, clamps, spanners, mild steel channels, screws, pins, wooden pegs etc. of standard sizes. Separate kits are used for cylinders and tonners.

(h) Health Hazards

Wet chlorine being corrosive, it forms corrosive acid with body moisture. Inhalation can cause respiratory injury ranging from irritation to death depending upon its concentration and duration of inhalation.

1. Acute Exposure

The first symptom of exposure to chlorine is irritation to the mucous membranes of eyes, nose and throat. This increases to smarting and burning pain. Irritation spreads to chest. A reflex cough develops which may be intense and often associated with pain behind the breast-bone. The cough may lead to vomiting. Cellular damage may occur with excretion of fluid in the alveoli. This may prove fatal if adequate treatment is not given immediately. Vomit frequently contains blood due to lesions of the mucous membrane caused by the gas. Other common symptoms include headache, retrosternal burning, nausea, painful breathing, sweating, eyes, nose, throat irritation, coughing, vomiting, increase in respiration and pulse rate. Massive inhalation of chlorine produces pulmonary oedema, fall of blood pressure and in a few minutes, cardiac arrest.

2. Chronic Exposures

Persons rapidly lose their ability to detect the odour of chlorine in small concentrations. On account of this, the concentrations beyond threshold limit value may exceed without notice. Prolonged exposure to concentrations of 5 ppm results in disease of bronchitis and predisposition to tuberculosis and concentration of 0.8- 1.0 PPM can cause moderate but permanent reduction in pulmonary function. Person exposed for long period of time to low concentrations of chlorine may suffer from acne, tooth enamel damage may also occur.

(i) First Aid - Trained Personnel and Equipment

In the plant trained first aider having the knowledge in the use of aid equipment and rendering artificial respiration should be available. First aid box with necessary contents should be available. Properly designed showers and eye fountains should be provided in convenient locations and they should be properly maintained. If oxygen is available the same should be administered by authorized person. Such training is imparted by civil defence.

1. General

Remove the affected person immediately to an uncontaminated area. Remove contaminated clothing and wash contaminated parts of the body with soap and plenty of water. Lay down the affected person in cardiac position and keep him warm. Call a physician for medical assistance at the earliest.

Caution: Never attempt to neutralize chlorine with other chemicals.

2. Skin Contact

Remove the contaminated clothes, wash the affected skin with large quantity of water.

Caution: No ointment should be applied unless prescribed by the physician.

3. Eye Contact

If eyes get affected with liquid chlorine or high concentration of chlorine gas, they must be flushed immediately with running water for atleast 15 minutes keeping the eyelids open by hand.

***Caution*:**	No ointment should be used unless prescribed by an eye specialist.

4. Inhalation

If the victim is conscious, take him to a quiet place and lay him down on his back, with head and back elevated (cardiac position). Loosen his clothes and keep him warm using blankets. Give him tea, coffee, milk, peppermint etc. for making good effect on breathing system. If the victim is unconscious, but breathing, lay him down in the position mentioned above and give oxygen at low pressure until the arrival of doctor. If breathing has stopped, quickly stretch him out on the ground or a blanket if available, loosen his collar and belt and start artificial respiration without delay. Neilson arm lift back pressure method is useful. Automatic artificial respiration is preferable if available. Continue the respiration until the arrival of the doctor. Amboo bag can also be used for this purpose.

(j) Fire & Explosion Hazards:

Chlorine may react to cause fires or explosions upon contact with turpentine, ether, ammonia gas, hydrocarbons, hydrogen, powdered metals, sawdust and phosphorus. Due to fire in the vicinity, the temperature of the containers rises excessively which results in explosion. In order to avoid explosion of the containers, remove all the movable containers from the fire zone immediately by wearing full protective clothing with respiratory protection. In the case of immovable containers, use water for cooling provided there is no leak.

(k) Emergency Measures

In case of leakage or spillage:

1. Take a shallow breath and keep eyes opened to a minimum.
2. Evacuate the area.
3. Investigate the leak with proper gas mask and other appropriate Personal protection.
4. The investigator must be watched by a rescuer to rescue him in emergency.
5. If liquid leak occurs, turn the containers so as to leak only gas.
6. In case of major leakage, all persons including neighbours should be warned.
7. As the escaping gas is carried in the direction of the wind all persons should be moved in a direction opposite to that of the wind. Nose should be covered with wet handkerchief.
8. Under no circumstances should water or other liquid be directed towards leaking containers, because water makes the leak worse due to corrosive effect.
9. The spillage should be controlled for evaporation by spraying chilled water having temperature below 4^{o}C. With this water crystalline hydrates are formed which will temporarily avoid evaporation. Then try to neutralize the spillage by caustic soda or soda ash or hydrated lime solution carefully. If fluroprotein foam is available, use for preventing the evaporation of liquid chlorine.
10. Use emergency kit for controlling the leak
11. On controlling the leakage, use the container in the system or neutralize the contents in alkali solution such as caustic soda or soda ash or hydrated lime.

Caution	**:**	**Keep the supply of caustic soda or soda ash or hydrated lime available. Do not push the leaking container in the alkali tank. Connect the container to the tank by barometric leg**

12. If container commences leak during transport, it should be carried on to its destination ormanufacturer or to remote place where it will be less harmful. Keeping the vehicle moving will prevent accumulation of high concentrations.
13. Only specially trained and equipped workers should deal with emergency arising due to major leakage.
14. If major leak takes place, alert the public nearby by sounding the siren.

15. Any minor leakage must be attended immediately or it will become worse.

16. If the leakage is in the process system, stop the valve on the container at once.

(l) Personal Protective Equipment

1. Breathing Apparatus

Various types of respirators and their suitability are as follows:

i) *Self-contained breathing apparatus*

This apparatus is equipped with a cylinder containing compressed oxygen or air which can be strapped on to the body of the user or with a canister whichproduces oxygen chemically when the reaction is triggered. This type of equipment is suitable for high concentration of chlorine in an oxygen deficient atmosphere

ii) *Air-line respirator:* Air-line length 90 mtrs. (max.) It is suitable for high concentrations of chlorine provided conditions permit safe escape if air supply fails,. This device is suitable in any atmosphere, regardless of the degree of contamination or oxygen deficiency, provided that clean, breathable air can be reached.

iii) *Industrial Canister Type Mask :* Duration: 30 min. for 1% Cl2

It is suitable for moderate concentration of chlorine provided sufficient oxygen is present. The mask should be used for a relatively short exposure period only.

If the actual chlorine concentration exceeds 1% by volume or oxygen is less than 16% by volume, it is not useful. The wearer in such cases must leave the place on detection of chlorine or experiencing dizziness or breathing difficulty.

2. Protective Clothing

Rubber, or PVC clothing is useful in massive exposure which otherwise creates mild skin burns due to formation of acid on the body.

Maintenance of Protective Equipment

a. Clean with alkali after every use.
b. Keep in polythene bag at easily accessible place.
c. Check them periodically about their suitability. Many times the seal ring of face mask gets hardened.

(m) Employees Selection

Pre-placement medical examination should be carried out of the persons to confirm that they are free from Asthma, Bronchitis and other chronic lung conditions. Follow up medical examination should be carried out once in a year.

(n) Employees Training

It is essential to impart training to the employees who have to face emergency.

This training should include following:

i) Instructions in the action to be taken in an emergency.
ii) Use of emergency kit.
iii) Handling of containers.

i) First aid.

ii) Use of protective equipment.

vi) Knowledge of Chlorine hazards.

i) Fire fighting.

(o) Neutralization of Chlorine

A suitable provision shall be available for emergency disposal of chlorine from the leaking container. Chlorine may be absorbed in solution of caustic soda/ soda ash /hydrated lime. If hydrated lime is used, the slurry must be continuously agitated forchlorine absorption. The neutralization can be carried out by:

LIST OF SAFETY SYSTEMS AT CHLORINATION PLANT

1. Breathing apparatus.
2. Emergency kit.
3. Leak detectors.
5.. First aid including tablets and cough mixtures.
6. Safety showers.
7. Eye fountain.
8. Personal protective equipments.
9. Fire extinguishers.

5.5.8 TROUBLE SHOOTING CHART FOR VACUUM TYPE CHLORINATOR

	Trouble	Cause	Remedy
1.	Required gas flow not achieved at start-up	a. Insufficient ejector vacuum caused by insufficient water supply by pressure or excessive back pressure	• Clean Y- strainer • Open solution valve, if it is closed • Clean solution line
		b. Leakage at vacuum line connection at outlet from flow meter, rate control valve, differential from flow meter, differential pressure regulator, and/or inlet to ejector.	Inspect each connection and remake if necessary.
		Vacuum line(s) if flexible, crimped	Replace vacuum tubing and arrange line to eliminate crimping.
2.	Required gas flow rate is not achieved on start-up following an extended period of shutdown	Insufficient ejector vacuum	
		Leakage at vacuum line connection at outlet of flow meter, rate control valve, differential pressure regulator, of inlet to ejector.	Inspect each connection and remake if necessary.
		Vacuum line, if flexible, crimped	Replace vacuum tubing and arrange line to eliminate crimping

		Leakage around flow meter gaskets	Inspect and align flow meter or replace gaskets.
3.	Flow meter float observed bouncing and/or maximum gas flow cannot be achieved during normal operation	Gas inlet filter of vacuum regulator dirty.	Replace gas inlet filter assembly.
		Rate valve dirty.	Clean rate valve
		Flow meter dirty	Clean flow meter.
		Ejector water supply pressure fluctuating too wide (float bounce) pressure or insufficient ejector vacuum.	Correct water supply as necessary
4.	Flow meter fails to indicate gas flow during normal operation but there is no out-of-gas is no out-of-gas indication	Rate valve plugged.	Clean rate valve
		Gas flow meter plugged	Clean gas flow meter.
5	No gas indication during normal operation	Gas supply valve(s) closed	Open gas supply valves.
		Gas supply exhausted	Replenish gas supply.
		Clogging of filter in vacuum regulator.	Replace filter
6.	Insufficient ejector vacuum	Y-strainer in water supply line is dirty reducing available supply pressure	Clean Y-strainer
		Back pressure is greater than value listed for one of the following reasons	• Open solution valve if it is in closed position • Clean solution line
		i) solution valve, if present, not fully open	
		ii) solution line, if present, partially blocked	
		iii) back pressure at point of application has increased above its original value	
		Ejector nozzle and/or throat dirty.	Clean nozzle and/or throat.
7.	Loss of gas feed	Dirty or plugged ejector nozzle	• Check for vacuum in ejector. • Clean nozzle.
		Insufficient water pressure to operate ejector.	Provide proper water pressure.
		No gas supply.	Replenish gas supply

8.	Flooded feeder	Dirt lodged on the ejector check valve seat	Clean or replace seat or o-ring

6.0 SUMPS, MBRs, BPTs and OHTs

6.1 General

The main function of sumps, Master balancing Reservoirs (MBR) and Break Pressure Tank (BPT) is to detain water as temporary storage for a specified detention time.

6.2.1 Union Sumps

Union sumps are located along Transmission Main for transmission of water from one Union BPS (Booster Pumping Station) to another Union BPS/Union MBR by pumping water . The capacity of Union sumps are 1 LL and above. These sumps are inter connected with suction well cum pump house from where water is pumped by means of Pump sets.

By virtue of design, hourly readings are recorded in the pumping Log sheet as well as by level sensor for transmitting levels through SCADA.

Care shall be taken that all man- holes are normally in closed position to prevent entry of flying debris, reptiles etc. Check shall be made and ensured that floating materials are removed

The additional parameter of data collected is turbidity present at suitable location, usually a point away *from Inlet pipe and away from" sump and suction well inter connection".* Sampling for turbidity shall be done Half-yearly to decide the necessity of cleaning.

Union Sumps are located at Madam(5 LL),Sowlur(14 LL),Kuppur(5 LL),Mukkalnaicanpatti(6 LL)

Warning	**:**	**Care shall be taken that the gravity pipe line does not go empty, even for short duration. as special team efforts are required to charge and re-commission the gravity main.**

Protective cement painting on the exterior exposed surface which is an important maintenance required atleast once in 5 years and this maintenance will increase the life ofv structure besides enhancing the aesthetic of the structure.

- Procedure for operation and maintenance of valves are as dealt pipeline maintenance.
- Daily check on effective functioning of air vent and man-hole close status has to made before starting pump.
- A red flag shall be put near the man-hole before entering in to the sump through the man-hole.
- If emptying and cleaning is done, a pply disinfectant (Sodium hypo-chlorite solution or Supernatant of Bleaching powder) to the walls and floor before start of filling.

6.2.2 Tapping Point

Tapping Point are located at different Locations on Transmission Main for transmission of water to Panchayat MBR/Panchayat Sumps .

By virtue of design, hourly readings are recorded in the Log sheet as well as by Pressure transmitter for transmitting pressure status through SCADA to master "control".

Care shall be taken that all man- holes are normally in closed position to prevent entry of flying debris, reptiles etc. Check shall be made and ensured that floating materials are removed.

Tapping Point are located at Madam,Billiyanur,Konanginaicanhalli,Indur,Athagapadi,Sogathur Cross Roads,Lakimpatti,Dharmapuri Municipality,Mukkanaican patti,package-III, Kuppur, Ollapatti, Nagampatti, Uthangarai

Protective cement painting on the exterior exposed surface which is an important maintenance required atleast once in 5 years and this maintenance will increase the life ofv structure besides enhancing the aesthetic of the structure.

- Procedure for operation and maintenance of valves are as dealt pipeline maintenance.
- Daily check on effective functioning of air vent and man-hole close status has to made before starting pump.
- A red flag shall be put near the man-hole before entering in to the sump through the man-hole.
- If emptying and cleaning is done, a pply disinfectant (Sodium hypo-chlorite solution or Supernatant of Bleaching powder) to the walls and floor before start of filling.

6.2.3 Panchayat Sumps

Panchayat sumps are located throughout the project to pump water mainly to Panchayat MBRs and in few cases to existing OHTs located enroute. Pump rooms are constructed nearby to house electrical panels. The capacity of sump ranges widely from 0.05 LL to 4.00LL. Sump sumps are connected to SCADA. Hence water levels will be recorded in pumping Log Sheet (Form-1)

Care shall be taken that all man- holes are normally in closed position to prevent entry of flying debris, reptiles etc. Check shall be made and ensured that floating materials are removed.
The additional parameter of data collected is turbidity present at suitable location, usually a point *away from Inlet pipe* and also *away from "sump and suction well inter connection".* Sampling for turbidity shall be done Half-yearly to decide the necessity of cleaning.

Open well submersible pumps (vertical type) are erected inside and they will be hanging with clamp supports provided on the cover slab.

Protective cement painting on the exterior exposed surface which is an important maintenance required atleast once in 5 years and this maintenance will increase the life of the structure besides enhancing the aesthetic of the structure.

- Procedure for operation and maintenance of valves are as dealt pipeline maintenance.
- Daily check on effective functioning of air vent and man-hole close status has to made before starting pump.
- A red flag shall be put near the man-hole before entering in to the sump through the man-hole.
- If emptying and cleaning is done, a pply disinfectant (Sodium hypo-chlorite solution or Supernatant of Bleaching powder) to the walls and floor before start of filling.

6.3.1 Union MBR

Union MBRs are available at Konangihalli, Athagapadi,Dharmapuri Municipality,Ollapatti. These Union MBRs have 16 m staging heights. Union MBRs are attached with RE-CHLORINATION systems and the services of the operating personal will be utilized for collecting manual data on water levels in the

reservoir. Level monitoring will be useful in avoiding over flows and dry-run of motive pump fitted for re-chlorination

Besides recording of the water levels, flow meter readings will also be made for monitoring on water transmission .

Protective cement painting on the exterior exposed surface which is an important maintenance required atleast once in 5 years and this maintenance will increase the life of the structure besides enhancing the aesthetic of the structure.

- Procedure for operation and maintenance of valves are as dealt pipeline maintenance.
- Daily check on effective functioning of air vent and man-hole close status has to made before starting pump.
- A red flag shall be put near the man-hole before entering in to the sump through the man-hole.
- Data on out-let wise valve opening for every 3 hours will help in monitoring the flow to different zones.

Warning	:	Care shall be taken that the gravity pipe line does not go empty, even for short duration. as special team efforts are required to charge and re-commission the gravity main.

6.3.2 Panchayat MBR

Panchayat MBRs are located throughout the project. These Panchayat MBRs have 16 m staging heights. Union MBRs are attached with RE-CHLORINATION systems and the services of the operating personal will be utilized for collecting manual data on water levels in the reservoir. Level monitoring will be useful in avoiding over flows and dry-run of motive pump fitted for re-chlorination

Besides recording of the water levels, flow meter readings will also be made for monitoring water transmission .

Protective cement painting on the exterior exposed surface which is an important maintenance required atleast once in 5 years and this maintenance will increase the life of the structure besides enhancing the aesthetic of the structure.

- Procedure for operation and maintenance of valves are as dealt pipeline maintenance.
- A red flag shall be put near the man-hole before entering in to the sump through the man-hole.
- Data pre –set valve opening on out-let wise should be recorded in the "sub-control centre"
- If emptying and cleaning is done, a pply disinfectant (Sodium hypo-chlorite solution or Supernatant of Bleaching powder) to the walls and floor before start of filling.

Warning	:	Care shall be taken that the gravity pipe line does not go empty, even for short duration. as special team efforts are required to charge and re-commission the gravity main.

6.4 OHTs

Few OHTs constructed under this project along with distribution system will be handed over to the respective local panchayats for further operation and maintenance.

6.5 Sub-Control Centers

In the following locations, sub-control centers will be located.

a. Sub-Control Center at Dharmapri

b. Sub-Control Center at Uthangarai

These sub-centers will receive instructions from Master Control and communicate with field stations. Data on operation and maintenance of Transmission Main, ITM and INW, all pumping stations, Re-cholorination stations on consumables, Tools for O&M and repair works, deployment of tools, equipments, Labour team for routine and emergency situations.

7.0 WATER METERS, INSTRUMENTATION, TELEMETRY & SCADA

7.1.0 WATER METER

7.1.1 Introduction

A water meter is a scientific instrument for accurate measurement of quantity of water distributed to the consumers. It also fulfils the need to know accurately the water produced and distributed.Water meter differs from flow meter in respect of the following points.

1. It is a quantity meter and not a flow rate meter.
2. Water meter is a mechanical device whereas flow meter may be a mechanical or an electronic device.
3. Water meter is always specified in two accuracies i.e. lower range and upper range accuracies whereas a flow meter it is specified in a single range accuracy.
4. The upper range and lower range accuracies are 2% and 5% of the actual quantity respectively for the water meter whereas it is variable for flow meter as per the customer's requirement.
5. Importance is not given for repeatability and linearity in the case of water meter whereas importance is given in the case of flow meter.

Water meters having sizes from 15 mm to 50 mm are considered to be domestic water meters and sizes from 50 mm and above are considered to be Bulk Water Meters.

Water meters are classified according to the operating principle, type of end connections, the standard by which the same are covered, constructional features, method of coupling between the counter and primary sensor, the metrological characteristics etc.

7.1.2. Sizing of Water Meter

1. Water meter has to be selected according to the flow to be measured and *not necessarily to suit a size of water main.*
2. The maximum flow shall not exceed the maximum flow rating.
3. The nominal flow shall not be greater than the nominal flow rating.

Important points on installation

- The meter shall be so installed that the longitudinal axis is horizontal and the flow of water should be in the direction shown by the arrow cast on body.
- Before connecting the meter to the water pipe, it should be thoroughly cleaned by installing in the place of the water meter a pipe of suitable length and diameter and letting the passage of a fair amount of water flow through the pipe work to avoid formation of air pockets. It is advisable that the level of the pipeline where the meter is proposed to be installed should be checked by a spirit level.
- Before fitting the meter to the pipeline check the unions nuts in the tail pieces and then insert the washers. Thereafter screw the tail pieces on the pipes and install the meter in between the nuts by screwing. In order to avoid its rotation during the operation, the meter should be kept fixed with suitable non metallic clamps. Care should be taken that the washer does not obstruct the inlet and outlet flow of water.

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

7.1.3 Testing & calibration of a water meter

1. The testing & calibration of a water meter is essential before putting it into use as it is a statutory requirement. It is also essential to test it periodically in order to ascertain its performance as during the course of meter working it is likely that its accuracy of measurement may deteriorate beyond acceptable limits.
2. A meter suspected to be malfunctioning is also tested for it's accuracy of measurement. A faulty meter if found to be repairable, is repaired and tested and calibrated for it's accuracy before installation. The metering accuracy testing is carried out at Qmin, Qt & Qmax. Separately. Where

Qmin : Lowest flow rate at which the meter is required to give indication within the maximum permissible error tolerance. It is as mentioned in IS779 and is determined in terms of numerical value of meter designation in case of ISO 4064.

Qt : The flow rate at which the maximum permissible error of the water meter changes in value.

Qn : Half the maximum flow rate Q max.

Qmax : The higher flow rate at which the meter is required to operate in a satisfactory manner for short periods of time without deterioration.

7.1.4 Preventive maintenance

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

7.1.5 Break-down maintenance

- Replace broken glass, lid and fallen wiper wherever noticed
- If a meter found not working, then it shall be removed immediately and sent to meter service workshop.
- In case of smaller size water meters, it is advisable to check cost benefit ratio before getting them repaired.

7.1.6 Trouble shooting for Mater meters

Sl. No.	Problem	Causes	Remedial action
1	Meter reads in reverse direction	Might have been installed in reverse direction	Check the arrow on the meter body and install the meter properly
2	Meter not recording	Impeller to register link broken	Remove meter and service it
3	Continuously moving pointer/digit rotates but no change in indicator	• Pointer and drum link missing • Drum deflect	• Remove meter and service it • Remove meter and service it
4	Dial/glass foggy	Climatic condition	Wait for climate change if it is rainy season
5	Meter suspected to be slow or fast	• Unsteady/turbulent flow at inlet • Defective/deteriorated magnet in the case of magnetic meters	• Clean the external filter/dirt box or inbuilt strainer • If doubt persists, overhaul
6	Bush/gland leaky	Gland deformity	Take out meter for testing and servicing
7	Regulator, head body leakage	• Regulator washer damaged. • Loose screw	Take out meter for repair
8	Physical damage including broken seal	Improper installation	Take out meter for repair and arrange protection
9	No water passes through meter	• Piston jammed and water meter acts as stop cock	Take out meter for inspection and repair

7.1.7 Prevention of tampering of Water Meter

In order to prevent tampering, following precautions are needed.

1. The water meters, shall be installed properly in the chamber with lock and key or in the C.I. covers with lock and key in order to avoid tampering.
2. The water meters must be sealed properly.
3. The water meters shall not allow reversible flow; it should register flow in forward directions only.
4. The water meter dials should be easily readable without confusions.

5. The lid, glass of water meters must be made up of tough materials as per IS 779 and shall be replaced timely.
6. The wiper or dial as far as possible is avoided.
7. In case of magnetically coupled meters, the proper material to shield magnets must be provided in order to avoid the tampering of such meter by outside magnets in the vicinity of meter.
8. Periodical inspection/checking at site is essential to ensure the proper working of meter.
9. Special sealing arrangements may be necessary and provided for bulk meters whereby unauthorized removal of the meter from the connection can be detected.

7.2 FLOW METERS

7.2.1 Introduction

Various methods are available for metering flow rate and total flow. Each method has its own specific characteristics, which are directed towards individual installation requirements.

In water industry flow rate meter is termed as flow meter and total flow meter is termed as water meter.

A wide range of standard terms are used to describe the essential performance characteristics of instruments and sensors. Some of these terms are as follows.

7.2.2 Accuracy

It is defined as the difference between the reading of an instrument and the true value of the measured variable expressed as a percentage of either full scale or true value of the measured variable i.e. either in terms of full scale or flow rate of the flow meter.

The accuracy remains constant within the rangeability irrespective of variation in flow rate.

7.3 Magnetic Flow Meter

a. Full bore (Inline) Flow Meter

Advantages of full bore magnetic (Inline) flow meter

i) Unobstructed flow passage

ii) No additional pressure drop

iii) Short conditioning section is required as it is insensitive to flow profile

iv) Smaller diameter flow meter can be used on bigger diameter pipe with the help of reducers having angle not more than 16^0.

Disadvantages

i) Air or gas inclusion causes error

ii) Minimum required conductivity of fluid 0.5 ms/cm.

iii) Isolation of pipeline is required for installation

iv)Vacuum creation may detach inner liner

b. Insertion Magnetic Flow Meter

Advantages

i) Less costly than that of full bore

ii) No isolation of pipe line for installation

iii) No moving parts

iv) Unaffected by changes in temperature, density, viscosity, electrical conductivity

v) Flow range setting can be optimized

vi) Suitable for water containing suspended solids

vii) Measures flow both the directions

viii) Un- affected by contamination and deposit

ix) Minimum maintenance

x) Good linearity

Disadvantages

i) Inferior accuracy due to point velocity measurement

ii) Long conditioning section is required

iii) Sensitive to vibration

iv) Periodic cleaning of electrode is required

7.4.1 Installation

It is essential to install the flow meter co-axially to the pipeline without protruding any packing or gasket into the water flow stream. In the case of ultrasonic meter the probes are welded on the pipeline which requires care to see that no projection is protruding in the pipeline. Long and disturbance free straight sections should be provided for uniformity. Installation should be vibration free as moving parts in the flow meter, when present, will get worn out in addition to the effect on overall accuracy of the flow meter.

Flow meters should be provided with battery backup in order to retain integrator reading during failure of electric supply.

7. 5 Maintenance of Flow Meter

Where deposits are to be expected in any flow meter, the same should be regularly inspected and cleaned. As these deposits affect the accuracy of the measurement by flow meter, Ultrasonic flow meter, may show erroneous reading in the presence of deposits.

7.6 Instrumentation

Instrumentation facilitates coordination of various water parameters which includes water level measurement at BPS, MBR etc

7.6.1 Maintenance of Level measuring Instruments

Float Operated Instrument

• Guide cable wound round a pulley should be lubricated. Other moving parts should also be lubricated.

• Zero setting should be checked. Float should be checked from corrosion point of.

Displacer, Electrical or Ultrasonic Instrument

• Clean the instrument and check for zero and range setting.

7.7 Pressure Measurement

In water supply network pressure parameter plays very important role in the transmission of water

This pressure or differential pressure measurement is accomplished by many means.

7.7.2 Electrical Pressure Transducer

Strain gauge pressure transducer, Potentio metric pressure transducer, Capactive pressure transducer

Variable reluctance pressure transducer Piezo electric pressure transducer are example for Electrical Pressure transducer

The advantages & disadvantages of electrical pressure transducers commonly used in water works are as follows.

7.8 Trouble Shooting

Vibration impact on the spring requires replacement in case of 'Bourdon tube' type pressure gauge.Loose electrical connections shorts in sensor leads, defective electrical/electronic sub-assemblies are common factors in trouble shooting electrical pressure transducers.

Periodical calibration is required to get the desired accuracy.

Maintenance of pressure instruments is essential for their proper working and accurate reading. It also improves the life and reliability of the instruments.

7.9 Water quality parameter monitoring

Monitoring water quality parameter helps not only to evaluate performance of various treatment process but also to identify potential locations of pollution during transmission of treated water and decide dosages of disinfection before supplying to consumers.

The parameters of water normally used for monitoring are as follows :

- Turbidity
- pH
- Coductivity
- Residual Chlorine

7.10 Telemetry

The inspection, monitoring and control of O&M of a water utility can be automated partially through telemetry. Telemetry enables regular monitoring of the above data on real time basis and the data is provided to anyone in the organization who can review the data and take a decision. In a Telemetry system probes/sensors will be used which will sense and generate signals for the level, pressure and flow in a given unit and transmit the signals by radio/by Telephone. Normally radio link is used and telephone line with modem is used as spare communication. Microwave satellite or fiber- optic transmission systems are also used for data transmission. The water pumping stations may communicate via a cable buried with the pipe.

However there may be locations where the main power may not be available and hence solar panels with a battery charger are used to power the remote terminal unit (RTU) and the radio. In urban

areas RTU s can communicate on cell phones and or packed radio networks. For remote locations satellite technology is also available.

7.11 Data Collection be Telemetry

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

7.12 Processing data from Telemetry

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

7.13 SCADA System

Instead of manual review of data collected by telemetry and initiating action manually, if telemetry is extended to include actions based on the data for remote control of pumps and other equipment then such a system is known as SCADA. Supervisory Control and Data Acquisition (SCADA) is a computer aided system which collects, stores and analyses the data on all aspects of O&M. The operating personnel can retrieve the data and control their operations and sometimes the system itself is programmed to control the operations on the basis of the acquired data. SCADA enhance the efficiency of the O&M personnel who are better informed about the system and hence are in full control of the operations. Whether in a telemetry system or a SCADA system up-to the minute real time information is gathered from remote terminal unit located at the water treatment plant, reservoir, flow meter, pumping station etc. and transmitted to a central control station where the information is updated, displayed and stored manually or automatically. In a SCADA system the information is linked to a supervisory system for local display, alarm annunciation etc. which may be linked to remote control of pumping operations or operation of valves etc.

7.13.1 Data collected in SCADA

SCADA systems will have probes/sensors which will sense and generate signals for the level, pressure and flow in a given unit and transmit the signals for storage and analysis in the computer. The signals are transmitted by radio, by Telephone, microwave satellite or fiber optic transmission systems. The signals transmitted are stored as data, analysed and presented as information. SCADA systems can

include the network diagrams of the distribution system of which detailed sketches of a particular area can be viewed by the operator if necessary to observe the current operating data such as flow, pressure, level or residual chlorine. SCADA systems in Water distribution are programmed for collection and processing of following information.

- to monitor levels in Service reservoirs, pressures and flows in a distribution system
- to monitor and store data on levels in SRs, or flows/quantity of delivered into a SR or pressures of distribution system and generate alarms for threshold values of levels, flows and pressures to initiate operation of valves and pumps
- to monitor and store data on operation of pumps such as Voltage, amperes, energy consumed, operating times and down times of pumps
- to measure and record chlorine residuals and generate alarms at thresh hold values of residual chlorinein the distribution systems.

7.13.2 Analysis of data from SCADA

SCADA systems can be designed to analyse the data and provide daily, weekly, monthly and or Annual reports or schedules. It also helps in monitoring the inventories on spare parts and plan requirement of spares. Responses for different scenarios such as seasonal changes or any emergencies can be programmed into SCADA. The information stored in the SCADA can be easily retrieved and analysed. Typical information that could be generated in the system include : Consumption patterns linked to the weather conditions, plots on pressures against flows, electrical energy consumption linked to consumer demands, record on system leaks, record on pump failures, areas with less chlorine residuals etc.

7.13.4 Limitations of SCADA

Availability of power supply is very essential to efficient functioning of the system. Wherever possible the RTU for flow meter or pressure sensor is provided power from electricity mains via a battery that acts as a buffer in case of mains failure. There may be metering locations for flow and pressure sensors without any source of power close by. In such cases Solar power may be one alternative. Initially installations at such locations may operate well but they are always subject to poor after sales service by vendors, vandalism and theft.

Ultimate improvement in water supply distribution system cannot be achieved through advanced application of technology like SCADA. The utility staff should have reached a reasonable level of managerial capabilities even with conventional methods of monitoring and control by adopting a holistic approach when the SCADA may further enhance their capabilities; but SCADA by itself is not the answer for poor or inefficient management.

8.0 SAFETY AND SAFETY PRACTICES

8.1 General

Dangers are also associated, as in any utility or industry, with Water Supply System Operation and Maintenance. There is therefore a need for safety practices during O&M. Physical injuries, bruises,

infection etc are not uncommon. Serious injuries like loss of limbs, eyesight, death due to electrocution may also occur but very rarely.

Adoption of safe practices and use of safety equipment may largely minimize occupational hazards.

Accidents do not happen – they are caused.

8.2 IDENTIFICATION OF ACCIDENTS

8.2.1 Source

In developing a safety program it is necessary to know the source of accidents. It is then possible to take precautions and corrective action. Besides knowledge of accidents in the utility itself, review of records or information at other water supply systems or in other utilities is helpful. Record of injuries/accidents maintained by the concerned department of labour, industries or factory department of the state can also be consulted. Other sources of information are safety manuals, insurance company brochures etc.

The main dangers at a water works system include, but are not limited to, the following:

Physical injuries arising from handling objects, falling objects, lifting objects, falls, tools and equipment,

(a) Physical injuries arising from handling objects, falling objects, lifting objects, falls, tools and equipment

(b) Stepping on or striking objects,

(c) Machinery,

(d) Toxic gases,

(e) Fire,

(f) Electrical shock,

(g) Collapse of trenches during repair of water mains.

8.3 Type of Injuries

To draw up a safety program, it is important to know the type of injury that is most prevalent in water supply systems.

The general injuries occurring in water supply systems are:

Bruises, cuts, sprains, fractures, burns, eye irritation and injuries, shocks, irritation by gases, permanent or temporary disabilities

8.4 SAFETY PROGRAM

Safety practices require good management. For years, there may be minor injuries like cuts and bruises, Safety organization is what you make of it.

Everybody on the O&M job shall know what can happen under certain conditions but each is busy with his own duties and responsibilities.

However, we need full-time attention to Safety.

8.5 SAFETY PRACTICE PROGRAM

8.5.1 Records of incidents

Keeping injury records is necessary for a safety program.

The record of accidents, whether minor or major, shall include items such as:

(a) Accident report

(b) Description of the accident

(c) Doctor's report

(d) Action taken

(e) Accident analysis

A summary of types and causes of accidents should be prepared periodically. A suggestive format is given below.

Type of Injury	Prime cause of Injury									
	Unsafe Act	Falls	Handling objects	Falling objects	Machinery	Electrical	Chlorine gas related	Earth sliding	Misc	Year Total
Bruises										
Eye Injury										
Cuts										
Burns										
Fractures										
Others										

8.5.2 Searching out accident

There must be a review of all reports by the management. There must be recommendations to avert such accidents.Hazards can be removed and will give increase in safety and confidence among working personnel.

• To examine records for conditions and situations that has caused accidents. Recall circumstances that led to the accidents. See if you can put your finger on some of the sore spots in your building,equipment or bad practices that are occurring.

• See what parts of the body are injured in the accidents. Protective gear may be required.

• Look around and inspect in an organized manner.

• Look around for potential causes of personal injury and fire and health hazards.

• Be on the watch for unsafe practices and doing the job the wrong way. Always be on the watch.

• Reduce risks in the workplace, equipment and materials. With the supervisory staff you can cut down the amount of personal handling of tools and materials. It may be cheaper to buy power equipment.

• See that the work is done in the right and safe way.

7.6 Motivation and Training

- For a good safety record, all individuals must be educated in safety measures. They must have conviction that accidents can be prevented. A safety programme must start on the new operator who has been freshly recruited or transferred from another work site. He must be exposed to the importance of safety, proper reporting and policies. Copies of Safety Practices should be supplied to him. Deeper training can be given to him subsequently after a few months. In the case of an individual who has been transferred, only the specific safety requirements in the new job are to be explained to him.

- Training will include how to perform the job. The plant supervisor must train the individuals in all aspects of plant safety. This will include dangers of electrical hazards, fire hazards, handling of tools and proper maintenance of tools to prevent accidents.Special instructions for specific work in confined environment such as pits, manholes, gas etc. must be given.

- The training must be continuous and not a one-time affair. During refresher education, case studies can be discussed. Victims of injuries can give their experience on how the accident happened. Safety posters placed at strategic points around the plant are a constant reminder and contribute to the continuing education.

- Proper guidance and use of tools, equipment must be given. Supervisors must continually check on proper use of tools. They must also see that the methods adopted are right and also safe.

- Motivate people to work safely when they are not being watched. Positive approaches like recognition of safety record, competitive interests etc. can be tried. Importance of good personal relations, a high morale and a sensitive management to the needs and interests of people plays a vital role in the programme of Safety Practices.

8.6 OPERATOR PROTECTION

8.6.1 Personal safety Equipment

The first step in controlling an unsafe condition is to remove the hazard mechanically. A secondary measure of protection is to provide personal protective equipment to the workman. Study of records has indicated the large number of injuries to various parts of the body due to non-use of safety equipment.

Personal safety equipment is designed to help protect the person's eyes, face, head, nose throat, lungs, ears, hands, feet and body.

Safety equipment can only supplement safe work/work habits but cannot protect the worker from unsafe actions.

Therefore there must be Broken/damaged safety tools and safety equipments should be disposed off without giving any chance/room to use them.

Supplying the appropriate equipment to the worker does not solve the problem. The employee must know when, how and where to use the equipment provided as well as its limitations. This requires constant and continuous training /reminding to use appropriate safety tools/equipment.
Training in the use the first-aid kit for immediate treatment of minor cuts, bruises and scratches.

8.6.2 Proper use of Tools

Some of the basic tool rules are:

- Always select the right tool for the job. Screwdrivers are not prying bars.
- Pliers are not wrenches
- Repair or replace broken or worn tools regularly
- Never use tools on or near moving machinery
- Be sure you have enough room, if the tool should slip
- Be sure you have good footing to prevent slipping
- Wear well fitted gloves except when hammering
- Never wear rings or loose clothing around moving machinery
- Always wear goggles whenever using any impact tools, power grinder or sharpener
- After using each tool, wipe, clean and replace in carrier or work belt. A greasy wrench can be dangerous
- Do not lay tools on top of ladders or where they may fall on someone working below
- Always use non-sparking tools on any job where explosive gases could be present.

8.7. SAFETY IN PLANT MAINTENANCE

8.7.1 Cleaning

Plant maintenance also called housekeeping or cleaning up is an important function of the pumping plant equipment. Maintenance requires an operator to handle machinery, manual and power tools, repair electrical equipment, enter pits, sumps, manholes etc. All these functions can pose a hazard and cause injury, fire, etc

Keeping the entire plant clean will provide a much nicer place to work. Just keeping the working areas free of tripping hazards will add safety in the plant. Cleaning should be performed when others are not exposed to danger or inconvenience. Wet floors become slippery. Use notices to warn people. Provide and use trashcans for used oily rags. Hazardous waste, acids and caustics should be cleaned up immediately.

Doorways, aisles, stairways and work places must be kept free of rubbish to reduce hazards of tripping and fire.

8.7.2 Guards, rails & Fencing

- Safe access to equipment will reduce dangers from falls.
- Ramps and stairs provide the safest means.
- Movement bye-passing ramps/stairs shall be avoided

- Lifting devices/trolleys shall be used when available.
- Fencing shall always be closed at Transformer Yard to prevent entry of stray animals/unauthorized people.
- There shall be restrictions to unauthorized people inside pumping plant/chlorination plant/ sumps/MBRs.
- All man-holes shall always be covered with cover.
- Before using inspection man-holes on pipeline or sump or suction well of pump house, intimate appropriate authority.
- Use hand gloves while operating panels/starters
- Spread insulation mats in front of panels/starters
- Put a temporary safety line/rope when shifting installations for repairs

8.7.3 Lighting

- Switch on lights when needed
- Flood lighting should be on at suitable places for safety and security of the complex
- Ventilation
- Ventilation is a major factor in water supply systems. This can be secured by:

(a) By open exterior windows or door louvres.

(b) By fresh air intakes and mechanical exhaust fans.

(c) By use of forced-draft fans.

(d) By use of man-holes on pipeline or sump or suction well of pump house

8.7.4 Safety Practices

When maintaining and operating equipment, the following precautions should be taken:

- Always stop the machine before removing any guard.
- Personally lock out all power before starting any equipment maintenance. Put a warning sign and tag on the lockout.
- Do not unlock any power, which has been closed by others.
- Block any counter balance or weighted machine to prevent dead movement.
- Have enough help and hoisting gear to handle heavy equipment safely.
- Block up under any heavy equipment when on jacks or hoists before starting work.
- Keep tools in a kit bag or belt (not on the floor).
- Keep goggles handy. Use them wherever needed.
- Don't be in a hurry. Haste makes accidents.
- An authorized person alone should handle overhead travelling cranes.
- Circuit breakers, limit switches, hook and wire should be checked/tested by authorized persons.
- Only standard hand signals, known to all, should be used.
- When loads are to be moved give a warning and make sure everyone is in a safe position.
- When using portable power tools use safety protective devices when operating grinding, chipping, buffing or pavement breaking equipment. Extension cords provide a tripping hazard.

- When working in damp or wet conditions use rubber mats.
- Electric tools should be grounded.
- For pneumatic tools use safety clamps and connectors.
- Electrical cords and air hoses should be kept away from oils, chemicals or sharp objects.
- Fire protection protection practices must be followed.
- In gas or electric welding, the operator must be trained.
- Storage of gas cylinders must be done with the same care as those of other gases in a water supply system.
- All safety valves in the system must be regularly inspected according to the maintenance schedule.
- Where forklifts are used, do not permit anybody, except the operator, to ride on it.
- Make sure the warning signals are operating.
- Check brakes. Make sure the forklift load is stacked properly before lifting or moving.

8.7.5 Lubrication safety

- Avoid lubricating machinery when it is running. If you have to do so, ensure that the lubricating point is at 30 cms. away from the moving part or the lubricant should be piped outside a guard.
- Wipe spilled oil or grease immediately.
- Never point a grease gun at anyone. Never squirt grease into your hands.

8.7.6 Safety in confined spaces

- Any place where oxygen deficiency or dangerous air contamination can occur and where ready ingress or egress for removal of a person is not available can be defined as a confined space. Some of such places are pits, manholes, inside of pipelines, and tanks.
- Oxygen deficiency occurs when oxygen is removed or when another gas displaces it.
- Safety checks must be carried out when working in such spaces.
- When working in confined spaces, ensure that sufficient air changes as required takes place.

8.7.6.1Chlorine

- Chlorine is considered as a hazard in the water industry.
- Chlorine gas is poisonous to humans.
- It is very corrosive when in contact with water.
- Extreme care must be taken when working with chlorine to prevent accidental injury to operators. Small amount can cause severe coughing and irritation of the nose, throat and lungs.
- The antidote is neutralization
- Consumption of milk and onions are first aids

8.7.7.Fire Protection

Very little attention is paid to fires. Three elements that cause a fire are (i) fuel (ii) oxygen and (iii) a means of ignition. Fire fighting is based on removing these elements.

8.7.7.1 Classification of Fires

Classification	Description	Extinguishing Medium
A	Fires including ordinary combustible materials like wood, paper, cotton, textiles etc where cooling effect of water is essential for the extinction of fire	• Water Soda acid type • Water type
B	Fire in flammable like oils, solvents, petroleum products, varnishes, paints where blanket effect is essential	• Foam carbon di-oxide • Dry powder
C	Fire involving gaseous substances under pressure where it is necessary to dilute the burning gas at a very fast rate with an inert gas powder	• Foam carbon di-oxide • Dry powder
D	Fire involving metals blanketing aluminium , zinc, potassium, where the burning metals is reactive to water and which requires special extinguishing media/technique	• Dry powder • Special dry powder for metal fire
E	Fire involving electrical equipment where the electrical non-conductivity of the extinguishing is of	• Carbon di-oxide / Dry powder • When electrical power switched off same as Class A and B

8.7.7.2 Fire extinguisher

There is no one particular extinguisher that is effective for all fires. One must be trained in the use of the different types of extinguishers, and the proper type should be located near the area where that class of fire may occur.

(a) Foam Type

Foam type of extinguishers will control Class A and Class B fires well. They, like soda acid, operate by turning upside down and require annual recharging. The foam and water type extinguishers should not be used for fires involving electrical equipment. However, they can be used in controlling flammable liquids such as gasoline, oil, paints, grease and other Class B fires.

(b) Carbon Dioxide (CO_2)

Carbon Dioxide extinguishers are common. They are easy to operate, just pull the pin and squeeze the lever. For maintenance, they must be weighed at least semi-annually. Many of these extinguishers will discharge with age. They can be used on a Class C (electrical) fire. All electrical circuits should be switched off, if possible, before trying to control this type of fire. A carbon dioxide extinguisher is also satisfactory for Class B fires, such as gasoline, oil and paint, and may be used on surface fires of the Class A type.

(c) Chemical Extinguishers

Class B and C fires and may work on small surface Class A fires.

1. The cartridge-operated extinguishers only require you to rupture the cartridge, usually by squeezing the lever. The maintenance is a bit more difficult, requiring weighing of the gas cartridge and checking the condition of the dry chemical.

2. For the stored-pressure extinguishers, the operation is the same as the CO2 extinguisher. Just pullthe pin and squeeze the lever. The maintenance requires a check of the pressure gauges andvcondition of the dry chemical.

8.8 SAFETY ASPECTS IN PUMPING STATION

8.8.1General Safety Aspects

Following safety precautions should be observed while working in a pump house.

i) No electric live part shall be kept exposed. Particular care should be taken not to keep the motor terminals, starter door, panel door etc. in open condition.

ii) Guard for pump – motor coupling and for extended shaft shall be provided.

iii) Top cover of the VHS (vertical hollow shaft) motor shall not be unnecessarily kept in dismantled condition.

iv) Helmet, gumboots, hand gloves, torch and emergency lamp etc. shall be provided to the workers.

v) Shock proof rubber matting shall be kept in front of panel and starters.

vi) Discharging devices shall also be provided to work safely on HT side of transformer.

vii) Fire fighting equipment suitable for electrical fire shall be provided. The fire extinguisher shall be thoroughly checked and recharged once in a year.

viii) Damaged wooden flooring, damaged grating etc. shall be repaired on priority.

ix) Safety railing shall be provided above all openings, unwalled edges of flooring and all such places vulnerable for falling or slipping of staff.

x) First aid box shall be kept at visible and accessible place. The first aid box shall be checked once in a month and all used items shall be replenished.

xi) Staff shall be trained in the following aspects to enhance safety awareness and skills to handle b safety aspects.

- Fire fighting
- Safety procedures and practices in electrical work
- First aid (general)
- First aid for electric shock.

8.8.2 SAFETY PROCEDURES AND PRACTICES (ELECTRICAL INSTALLATIONS)

General guidelines and precautions as follows should be observed for safe working in electrical installations.

(a) Work on Medium Voltage Mains and Installations

1. Unless a person is authorized to work on live low and medium voltage mains and apparatus, all mains and apparatus to be worked upon shall be isolated from all sources of supply, before starting the work, proved dead, earthed and short-circuited.
2. For earthing and short-circuiting, only recognized methods should be used. Measures such as removing fuses shall be taken against the inadvertent energizing of the mains and apparatus.
3. Only competent, experienced and authorized persons shall work on live mains and apparatus, and such persons should take all safety measures as required under the Indian Electricity Rules, 1956.
4. Warning boards shall be attached on or adjacent to the live apparatus and at the limits of the zone in which work may be carried out.
5. Immediately before starting work, rubber hand gloves shall be thoroughly examined to see whether they are in sound condition. Under no circumstances shall a person work with unsound hand gloves, mats, stools, platforms or other accessories and safety devices.

(b) Work on High Voltage Sub-Station/Transformer Station

All high voltage mains and installations shall be regarded as alive and a source of danger and treated accordingly unless it is positively known to be dead and earthed.

No person shall work on high voltage mains or apparatus unless covered by a permit-to work and after proving the mains dead except for the purpose of connecting the testing apparatus, etc. which is specially designed for connecting to the live parts. Incoming high voltage power supply shall be disconnected by opening AB switch/GOD. As additional precaution, the DO fuses or HG fuses shall be disconnected. Breaker on HV side shall be kept in open (off) position.

8.8.3 General Precautions in Electrical Installations

It is always necessary to observe the following rules as precautionary measures in electrical installations.

i) Try to avoid work on live mains which should be switched off before working.

ii) If it is not possible to switch off the mains, make sure before working that your hands or feet are not wet and insulated footwear and rubber hand gloves are worn.

iii) Place yourself in a safe and secure position to avoid slipping, stumbling or moving backward against live conductors or apparatus. Do not rely for protection upon the care assumed to be exercised by others.

iv) In the event of near approach of a lightening storm, all outdoor work on electrical system should be stopped.

v) Make a habit of being cautious. Be on the lookout for danger notice plates, danger flags, warning boards and signals etc. Warn others when they seem to be in danger near live conductor or apparatus.

vi) Never speak to any person working upon live mains or apparatus, unless the person doing the work is aware of your presence and that you are working on electrical system.

vii) In order to rescue a person who has got an electric shock, if there is no other insulator available for rescuing, use your feet rather than hands.

viii) When attending electrical work, be sure that the floor is covered with rubber mat. Concrete floors are dangerously conductive.

ix) When working on high voltage try to keep your left hand in the pocket i.e. avoid your left hand to get in contact with any live conductor or metallic casing of an apparatus or metal pole or cross arms.

x) Do not work in such a place where your head is liable to touch the live mains.

8.8.4 First Aid for Electrical Shock

Standard printed instructions for first aid against electric shock shall be framed and displayed at prominently visible and accessible location.

In most of the cases the electric shock due to accidents is momentary and the contact with the live wire is imperfect. In such cases breathing stops momentarily, but due to the shock, the victim becomes unconscious, and heart beats become weak. The most urgent and immediate care for the victim is that he should be given immediate artificial respiration in the manner detailed below, and artificial respiration should be continued till the victims starts breathing normally. It should be borne in mind if the artificial respiration is stopped just after the victims recovers, he is liable to become unconscious again. In some cases the artificial respiration need to be continued for 6 to 8 minutes.

8.8.4.1 Artificial respiration

At the time of accident due to electric shock, proceed as follows.

i) When any one gets a shock, the first and foremost duty of the observer is to break the contact of the live mains and body either by switching off the main supply, or the body should be rolled away with dry wooden stick. If a stick etc. is not at hand, a dry piece of cloth should be used. Detach the body from the live mains, or if that is also not available, the loose cloth such as coat or shirt of the victim should be pulled without touching his body.

ii) See if the operator's clothes are smoldering; extinguish the spark first.

iii) Check up if the patient is breathing or not. If he is not breathing, immediately start artificial respiration as detained below until medical aid arrives.

iv) Lay the patient so that no pressure on the lungs of the patient is exerted to facilitate artificial respiration.

Method – I

Lay the patient. Kneel over the patient's back, and place both the hands on the patient's thin portion of the back near the lowest rib in such a manner that the fingers remain spread on the sides and the two thumbs almost touch each other and are parallel to spine. Now press gradually and slowly for about 3 seconds by leaning your hands forward. The patient should be kept warm.

Now relax the pressure slowly and come to the original kneeling position for about 2 seconds. Repeat the process for about 12 to 15 times in a minute so as to expand and contract lungs of the patient to

initiate breathing. The process should be continued with great patience and in no case undue force should be used.

Method-II

When the patient has got burns etc. on his chest or anywhere on front side, then the patient should not be laid as in Fig.11.3. Appropriate position of laying in such case is on back as shown Fig.11.4 with a pillow or rolled cloth, mat, bed sheet under his shoulders. The clothes of the patient shall be immediately loosened before starting the process of artificial respiration.

a) Hold the patient just below the elbow and draw his hand over his head until they are horizontal. Keep them in that position for about two seconds. Now bring the patient's hands on to his sides kneeling over the patient's hands so as to compress them down. After 2 seconds repeat the process again.

b) If operator has got burns only, the same should be dressed properly. Oil should never be used on the burns. After burns are dressed properly, he may feel better. It is important to note that the one who has received electric shock is liable to get an attack of hyperstatic pneumonia. So it is necessary to keep him warm for at least a day.

8.8.4.2 SAFETY FROM ELECTICAL HAZARDS

General rule

1. Only trained and qualified persons should be allowed to operate and maintain electrical equipment.
2. When servicing any electrical appliance, kill, lockout and tag all power coming to it.
3. Be sure of proper footing so that one does n't fall onto a live wire. Always make sure that the wire is not live. Use a pencil type tester.
4. Hand tools must have insulated handles.
5. Insulated mats must be provided before electrical controls.
5. Ensure that all electrical systems, equipment etc. are properly grounded.
6. Remove metallic rings, watches, eye glasses. Don't use metallic tape measures or metal ladders.
7. Always mount and protect wires and cables to prevent tripping by persons.
8. Electrical controls should be in good working order, easy to reach and plainly identified.
9. Be sure there is someone to help in case of emergency. Don't become careless or overconfident.

1.Have an adequate supply of a good eyewash at all times.
2. Keep several fire blankets in an easily accessible location.
3. Special fire extinguishers, clearly labelled and checked for monthly charge, for chemical and electrical use should be openly mounted.
4. Emergency numbers for fire and medical help should be clearly and permanently displyed above everyphone.
5. All employees, and especially laboratory technicians, should have extensive, regularly refreshed, first aid training

8.8.4.3 Electrical First Aid

1. Immediately free the victim from the live conductor by use of a dry wooden stick, (such as a broom or shovel handle), piece of rubber hose or plastic pipe, or other nonconductor. Never grab the victim or the wire with bare hands, or you will suffer the same consequences.

2. If unconscious or not breathing, artificial respiration should be started immediately and continued until relieved by doctors or professional.

3. Protect from shock by keeping the victim warm and quiet.

8.8.9 SAFETY PRACTICES DURING REPAIR AND OPERATION ON WATER MAINS

8.8.9.1 Traffic Control

1. Warning signs must be placed well ahead of the work area. Signs, barricades and used tyres can be used.
2. Vehicles can be parked between work area and the coming traffic.
3. Use red warning lights or flashers during the night.
4. Use a flag man for one way operation.
5. Traffic police must be informed and their help taken.

8.8.9.2 Safety practices during pipe line works

1. Excavations should be closely watched. Type of soil must be studied and necessary precautions taken to provide adequate side slopes or to shore up the trench. The proximity of poles and buildings must be taken into consideration.
2. All soil must be stacked at least three feet from the edge of the trench.
3. Repair of broken mains is a hand job. The ground is usually saturated or washed out. Care must be taken to protect other utilities especially electric cables which can be dangerous. Welding must be done in dry conditions.
4. The workmen must use safety hats and other protective equipment.
5. Only one trained and experienced man should give signals to a crane operator.
6. The inspection of the equipment to be used should be done before it is sent to the site. In case of a burst main, the advance crew should carry plans showing the location of valves to be closed, barricading equipment, signage, valve and chamber keys etc. Portable pumps to drain out the water should also be sent.
7. The pipe for replacement must be blocked to prevent it from rolling. Proper equipment should be used when lowering it into the trench. Sufficient men should also be engaged.
8. When the job is completed, cleaning up must be done to prevent hazards to others.