APPENDICES

Appendix	Title of Appendix	Page

APPENDIX B.1.1 MONITORING THROUGH INFORMATION CONTROL TECHNOLOGY

1.1.1 OUTLINE

Understanding the condition of sewage to be treated is very important for efficiently operating a STP. In this manner, the condition of sewage to be treated can be grasped simultaneously by making use of systems for monitoring through information control technology. This can be done by centralized monitoring using systems such as SCADA (refer to Sec. 6.6 of Part B manual), that helps to determine operating methods.

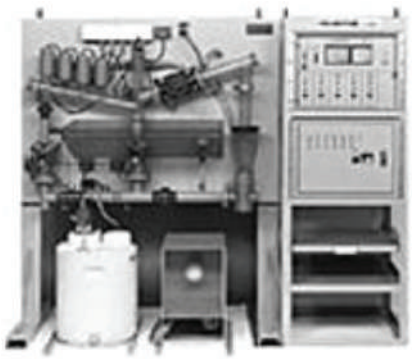
Items to be measured include DO, SS, pH, ORP, COD, influent flow rate, effluent flow rate, and return flow rate. Measuring equipments include equipment for measuring single items to those that can make several kinds of measurements simultaneously. Equipments that can make several measurements simultaneously, are described below.

1.1.2 EXAMPLES OF MEASURING EQUIPMENT

Features

- Monitors the environmental water quality of rivers, lakes, other water bodies and the water quality of effluents, etc.
- Built-in automatic cleaning and calibration functions greatly reduce maintenance work.
- Integrated sensors are employed to reduce unit size and save space.
- Measurement items are water temperature, pH, electrical conductivity, turbidity, dissolved oxygen

A typical equipment is shown in Figure B1.1-1



Source: DKK-TOA CORPORATION
Figure B1.1-1 Automatic Water Quality Monitor

MONITORING EXAMPLE FROM JAPAN

1.1.3.1 Sewerage (Public Works Bureau) in the City of Osaka

- Operation and Maintenance (O&M) of Sewerage System

It is important to properly operate and maintain facilities such as sewers, pumping stations and sewage treatment plants so that these facilities play their roles effectively.

- Operation and Maintenance (O&M) of Sewage Treatment Plants

  STPs are operated on a 24-hour basis in order to treat wastewater continually for ensuring effective operation of sewage treatment plants in response to varying inflow rates. Various water quality examinations are conducted at plant laboratories to monitor the quality of the final effluent. A typical laboratory is shown in Figure B1.1-2 and Figure B1.1-3

Figure B1.1-2 Water Quality Analysis

Figure B1.1-3 Central Control Room

1.1.3.2 Bureau of Sewerage Tokyo Metropolitan Government

Sewage Reclamation Centre

- Sewage reclamation centres must process sewage as it flows non-stop, 24-hours per day. If the centres do not function properly, pollution would spread quickly to rivers and the sea.
- In order for microorganisms, which are the main players in the treatment process, to function properly and discharge sewage debris as sludge, the water quality of influent and effluent is tested and maintenance, inspection, and monitoring of equipment are performed constantly.

A typical centre is shown in Figure B1.1-4

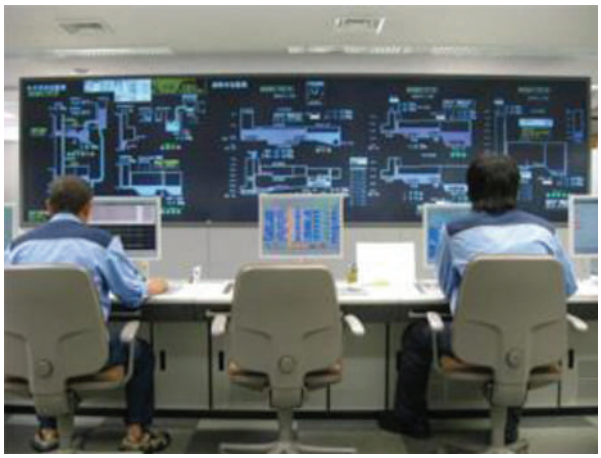


Figure B1.1-4 Main Monitoring Room in Water Reclamation Centre

Note: Tokyo Metropolitan Government calls a “sewage treatment plant” a water reclamation centre.

APPENDIX B.1.2 DATABASE FOR EFFECTIVE O&M

Effectively collecting, analyzing, reporting, distributing, storing and archiving data irrespective whether electronic, paper, audio, image, or video have become key aides to effective and efficient operations.

In recent years, raw data is being increasingly managed by computers.

A computerised maintenance management system (CMMS) {also called a computerised work management system (CWMS) or a work management system (WMS)} enables utilities to manage maintenance work and minimise equipment downtime cost-effectively. The system is designed to plan, schedule, and manage maintenance activities; control parts inventories; coordinate purchasing activities; and help prioritise long-term asset investment needs.

A CMMS typically consists of the following six components:

- Work management (corrective, preventive, predictive maintenance scheduling, activities and procedures);
- Equipment inventory (an inventory and description of equipment and support systems requiring maintenance, along with other technical or accounting information); Electrical equipment of ledger is shown in the next page.
- Inventory control, tools and materials management (materials, tools, spare parts management, scheduling and forecasting);
- Purchase or procurement (maintenance-related requisition, procurement, and accounting);
- Reporting and analysis (standard and ad hoc reports); and
- Personnel management (staff skills, wages, and availability).

If a database containing the items mentioned above can be used, costs can be easily managed, and the data can be used to prepare budgets.

A typical sample ledger for electrical equipment is shown in Table B1.1-1 overleaf.

Table B1.1-1 Ledger for electrical equipment

		Classification		File No.	

Name		Location		Related Ledgers	( )	( )
		Fixed asset No.			( )	( )

Items on name plate	Capacity			Rotor	Voltage	V	Others	Insulator type							
	Number of poles				Current	A		Insulation resistance allowance							
	Phase				Type			Rotating direction							
	Frequency	Hz		Rotation rate		rpm		Lead wire direction							
	Voltage	Primary V	Secondary V					Impedance voltage							
	Current	Primary A	Secondary A	Specification			Test performance chart	Frequency							
	Mode1			Manufacturer				Voltage							
	Specification			Lot No.				Current							
				Date of mfg.				Loss							
	Mode1	( )	( )	Reducer	Reduction ratio			Measuring position	1) mm	2) mm					
	Sleeve Diameter	( )	( )		Mode 1				3) mm	4) mm					
	Sleeve Length						Related charts	Name	Chart No.		Name		Chart No.		
	Coil Wire Type				Manufacturer										
	Coil Wire Thickness			Starting resistor	Voltage	V									
	Coil No. of coils				Current	A	Special notes								
	Coil Total weight				Resistance	Ω									
					Mode 1										
					Manufacturer										

Source: JICA, 2011

APPENDIX B.1.3: Evaluation of O&M of STPs in India – CUPS/68/2007

Conclusions and Recommendations

1. Mostly influent to the STP was found to contain lot of solid wastes including plastics, pouches etc. that may cause wear and tear of pumps and machinery and reduce deficiency of treatment, specially in case of UASB process where the feeding pipes and overflow weirs/ V-notches in division boxes/effluent gutters, are chocked/obstructed, thus, also resulting in reduced STP capacity. It is, generally, observed that mechanical screens installed in STPs/SPS are out of order, mainly because these are not regularly sun and also due to poor maintenance. Comprehensive scheme for providing soid waste management in all the towns including public awareness, institutional strengthening, etc. need to be implemented. As an immediate solution to the problem, specially in UASB process, fine/mesh screens can be put in place of ordinary bar screens. Larger size of feeding pipes with more frequent cleaning can also solve this problem.

2. Staff/officers/engineers engaged for O&M at some STPs are not fully familiar and aware of the subject of sewage treatment. They are not trained in the O&M of the STPs. Proper training programme needs to planned and implemented for all the engineering level staff/officers, who are deputed for O&M of STPs. This should be followed by training for operators as well as chemists, who perform sampling/testing work.

3. At most of the STPs, either O&M manual is not prepared or it is not available/used, or it is not comprehensive enough to include various steps/procedures to be followed in day-to-day O&M of the plants as per design, so as to have desired quality of treated effluent. O&M manual should spell out the procedure of reporting and recording of all the data/parameters including quality of wastewater in various units of the plants.

4. Polishing ponds (in case of UASB process) and Waste Stabilisation Ponds (WSPs) are mostly found accumulated with sludge resulting in reduced capacity/detention time in the tank. This also effects the quality of treated effluent due to sludge flowing out with it. Sludge levels should be checked regularly and the ponds should be cleaned off deposited sludge accordingly.

5. In case of polishing ponds or WSPs, it is found that single unit of these ponds have been provided in some STPs. In such cases, it is very difficult to clean the accumulated sludge /silt without closing the STP. Hence, it is important that at least two units of such ponds are provided at each STP. Also, in case of big ponds/channels wide and long partition/baffle wall need to be provided for easy access for inspection/repairs.

6. Sludge in UASB reactors are not withdrawn regularly based on its level and concentration in the reactors which results in sludge flowing with the effluent in polishing ponds and thus poor quality of treated effluent. Regular checking of sludge level and its concentration in the reactors is essential for proper sludge withdrawal.

7. Due to improper removal of filtrate from sludge drying beds, subsequent removal/withdrawal of sludge from sludge drawing beds/reactors is not possible in a desired manner, as the capacity of sludge drying beds is reduced. Hence, filtrate from the beds and sludge from the reactors/sludge drying beds need to be taken out regularly in a proper way.

8. It is important to prepare daily status report to record occurrence of problems in respect of running, functioning, repair, maintenance etc. of all the equipments, units, facilities etc. installed in each STP, so that the problems, if any, can be solved as and when applicable. This will also serve as feed back for future planning and execution as well as tool for monitoring the performance of STPs at a higher level.

9. Some of the STPs don't have sufficient baffle walls and also, sufficient length of overflow weirs at their final outlets in case of UASB polishing ponds and WSPs, resulting in poor effluent quality. Baffle walls should be constructed for the whole length of the pond width so that scum/sludge does not flow out with the effluent. Similarly, longer overflow weirs will ensure less approaching velocity of flow and subsequently, efficient solid liquid separation.

10. In view of frequent rusting/damage of iron/MS parts/accessories installed in STPs/SPSs due to sulphur action, such items e.g. railings, screens, platforms etc., as far as possible, should be manufactured in stainless steel, as seen in case of STPs being constructed/renovated in Tamil Nadu, Maharashtra etc. Moreover, small electric installations such as motors, flow meters, starters, etc put up for operation of aerators, screens, grit removal mechanism, gates etc. should be covered with temporary sheds (PVC) to protect against rain water, dust etc.

11. It is observed that in most of the towns specially, in UP, Bihar and even Delhi, where there is acute shortage of power supply, a standby arrangement during power cut/failure does not generally exists to meet the power requirement for running the plant. Frequent and long power cuts and subsequent sudden discharge into the STP also causes shock load to various units of STP, even in UASB and WSP processes, thus adversely effecting the efficiency of treatment. Hence, alternative standby arrangement in the form of generators along with sufficient funds for fuel need to be provided to ensure continuous operation of STPs. Intermittent operation of STPs will not help in achieving the desired quality of treated effluent and thus minimising the river water pollution. In addition, unless continuous power supply is available effluent quality parameters specially, BOD, etc, cannot be tested accurately.

12. Majority of State Govts/implementing agencies are not able to provide sufficient and regular funds for O&M of STPs resulting in their unsatisfactory performance. The annual cost of O&M of sewerage system and STPs in a town varies from 5 to 10 %, depending on the quantum of pumping (stations) and type/size of STP. It is also observed that the revenue from STPs is negligible or far less than the expenditure required to be incurred for proper O&M of the STPs in all cases. In case of STPs constructed with central funding under NRCP by MoEF, O&M cost is to be borne by the State Govts. If the amount for O&M of STPs cannot be provided on regular basis by the State Govts. then the matter needs to be looked into at the highest level, whether further new works should be taken up under the programme.

13. Sometimes, the staff/engineers engaged in O&M of the STPs are frequently transferred so that their experience and know-how does not get transferred to their successors and is thus not available for O&M of the STP. So the O&M staff/engineers should be deputed at a plant for sufficient number. of years and their experience and knowhow transferred to their successors in a planned and systematic manner.

In case O&M is being conducted privately through an annual contract, the agreement should be such that the same contractor continues after the initial period of one year, subject to its satisfactory performance. As a matter of fact, O&M of a STP should be included in the main construction contract for a period of at least five to 10 years. This arrangement has been giving good results in some of the STPs, namely at Channai, Panji, Nasik etc. where this practice has been adopted.

14. Mostly the result of tests for effluent quality being carried out by various independent agencies are not fed back to the staff managing the O&M of the STPs. As a matter of fact the results of the tests, especially, if they are adverse, should be informed to the operating staff as soon as possible so that corrective measures can be taken at site accordingly. Also, testing of effluent for fecal coliform is not being conducted in most of the plants which is one of the most important indicator in abatement of pollution of rivers.

15. In some of the states, specially in UP, O&M of the STPs in some towns is being done by local bodies which do not have qualified, experienced and knowledgeable staff who can supervise the O&M of the STPs. Local bodies have engaged private agencies on contract for O&M of these STPs but their performance is very much unsatisfactory. This arrangement of O&M of STPs by local bodies, where competent staff is not available, may not last long. In such cases, if it is essential for O&M to be done by local bodies only, staff / engineers with experience in O&M of STPs should be transferred / appointed from the implementing agency, namely UPJN who have constructed the plant.

16. A holistic approach for abatement of pollution of rivers need to be adopted, as on one hand population and other human activities are increasing and on the other hand the problem further gets compounded due to declining minimum flow, as a significant quantity of water is abstracted upstream of a town for irrigation/drinking purposes. This is specifically applicable in case of Yamuna in Delhi, where all the water is withdrawn from the river upstream of Wazirabad barrage.

17. It is estimated that out of 3267 MLD of sewage generated in Delhi, treatment capacity exists for only 2376 MLD, but only 1530 MLD of total sewage generated is treated at the STPs. Thus only 64.37% of treatment capacity of STPs is utilised. Under utilisation of capacity of treatment is on account of (i) deficiency in sewerage not work (settlement/silting of trunk sewers) and (ii) improper O&M of conveyance system and pumping stations. Also, it is important to note that treated sewage is mostly discharged into storm water drains (17 nos), which carry untreated sewage and join river Yamuna. Storm water drains carry sewage from unsewered areas, overflow from manholes/pumping stations and treated/untreated industrial wastewater. In order to have desired quality of river water in Yamuna at Delhi, the following immediate measures have to be taken :-

    a. Rehabilitation/desilting of trunk sewers.

    b. Provision of sewerage net work in unsewered areas.

    c. Augmentation of treatment capacity of STPs as per requirement.

d. Use of treated effluent for irrigation and other purposes.

e. Proper O&M of the sewerage system and STPs.

18. Sewage treatment with WSPs (anaerobic, facultative and maturation ponds) is most economical in terms of capital as well as O&M cost and is suitable for small towns where sufficient land is easily available. However, certain basic precautions e. g. providing proper weir length and baffle wall(s) at the outlet of ponds during construction; and proper O&M in respect of cleaning of sludge deposited in ponds at suitable intervals (6 to 12 months) and arresting algal/hyacinth growth are minimum requirements which have to be kept in mind for achieving desired results.

19. Conventional treatment process, namely ASP/trickling filter is very suitable in case of large towns, where land is scarce, provided there is no shortage of power and funds to meet capital and O&M costs. In some of the large towns UASB process has been provided under NRCP, as it is economical in respect of O&M as compared with ASP. It is observed that in some cases desired results are not achieved as O&M agencies are not paying importance to the intricacies involved in the treatment process, namely uniform feeding to the plant/reactor, proper grit removal and withdrawal of sludge from UASB reactors, regular cleaning of accumulated sludge from polishing ponds etc. Improper O&M of these plants is giving a bad impression about UASB technology, which otherwise appears to be quite appropriate for sewage treatment for most of the towns in our country.

20. In places, where land availability is very scarce, sewage treatment using FAB (Fluidized Aerobic Bed) reactor, in which biomass grows on small elements (media) that move along with the water in the fluidized bed state, can be the most appropriate choice. The movement is caused by bubbling air at the bottom of the reactor. The system has been provided in a few towns under NRCP, but poor O&M might give a negative signal in adoption of this process of treatment.

21. Schemes for providing interceptors with nalah-tapings and main/trunk sewers along with STPs (down stream works) are being implemented under NRCP by MoEF in various towns which are situated on the bank of different rivers and are polluting the river waters. Upstream works i.e. internal / branch sewers including house connections etc. for a town have to be taken up by the State Governments through their own resources so as to have a holistic approach in abatement of pollution of rivers. This will also help in solving the problem of weak sewage reaching the STPs for treatment. Besides, it is also observed that sewerage schemes in various towns are being sanctioned / implemented by different agencies / departments under different Central / State plans, e.g. NRCP by MoEF, NURM by MOUD etc. Unless proper coordination exists between different agencies / departments, implementation of sewerage schemes may lead to defective planning / execution and duplication of works, without achieving the desired goal. Thus, as far as possible, all the sewerage schemes for a town should be sanctioned / implemented under a single funding agency / Ministry.

22. Out of the 68 STPs inspected for their performance evaluation, it is observed that O&M in case of 40 STPs is found to be poor or very poor for various seasons. There is no mechanism for physical monitoring of the performance of STPs constructed and commissioned under the NRCP by MoEF.

These are seldom visited by higher officers of NRCD in MoEF for their inspection so as to get first hand information on the status of O&M of STPs by the State Govts./implementing agencies. Moreover, the scope of work of Project Management Consultants (PMC), appointed by the Ministry for implementation of YAP - II, includes monitoring of O&M all the STPs constructed in Delhi, UP and Haryana under YAP – I. But it is understood that no action has been taken by NRCD in this respect since the appointment PMC two years ago. Regular monitoring of all the STPs for their performance evaluation at central level (CPCB) twice a year by having own independent sampling/testing of wastewater need to be carried out for bringing improvement in O&M of STPs and get the desired quality of treated effluent.

23. It is understood that projects based on generation of electric power from biogas, which is being produced as a result of digestion of sludge in STPs, are eligible for CDM (Clean Development Mechanism), as it will help in reducing and stabilising the emissions due to methane which is a green house gas. Based on the potential of biogas/power generation from STPs, expenditure on O&M can be offset by earning 'carbon credits' on recurring basis. It is, therefore, recommended that a feasibility study should be done for taking up a CDM project in case of any one of the STPs by DJB in Delhi as it can be a perennial source of revenue generation.

In view of importance of abatement of pollution and preservation of rivers and other water bodies, proper sewage treatment, its O&M and subsequently, optimum utilisation of treated sewage for irrigation and other purposes needs to be given higher priority by Central/State Governments. urgently. Looking into the overall situation of O&M of the STPs, it can be concluded that sewerage and sewage treatment is generally not considered a priority item by the State Governments./local authorities/implementing agencies. So, unless importance/priority is given by them, the situation may become bad to worse.

APPENDIX B.2.1 TROUBLESHOOTING IN SEWERS

Table B2.1-1 Troubleshooting in sewers

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	House sewer does not flow	Toilet floor below road elevation	Raise the toilet floor	Install small lifting arrangement
		House sewer pipe broken	Relay the sewer	Go for new connection
		Solids are choking the sewer	Use a kraite from the terminal chamber	Dig out the sewer and relay
		Connection is made to public sewer by Y or Tee junctions	Dig open the junction in road and rectify	Insert a manhole in public sewer
		House connection may be passing through bends	Dig it out and relay in straight alignment	Construct a new sewer in another alignment
		Roots of trees might have grown into the sewer	Expose the pipe and shear off the roots	Dig out and relay the sewer
2	Septic tank emits foul smell	Organic matter has accumulated at the bottom and become concentrated	Raise the vent higher than the roof for free air passage	Take a sewer connection if available
3	Septic tank effluent smells bad odour	This is always the case when discharged freely	Provide a leach pit and then let it out to road drain	Provide trees for evaporating the effluent
4	Sewage overflows from manholes	The sewer to the next manhole is choked (or) some other downstream sewer is choked	Open out downstream manholes to find out where the sewage is not flowing	Use jet rodding machine at the downstream end and jet the sewer at the high end
		The sewer has collapsed in the next reach or somewhere else downstream	Use a bucket cleaning machine to establish the broken sewer or not	If established, dig out and provide new sewer pipe after temporary blocking upstream

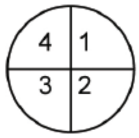
No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
5	Sewage level does not go down at all in the sewage pumping station	The sewage pump sets are very old and worn out (or) ground water is infiltrating into the sewers	Check the TDS by a pocket meter every hour to find out abnormalities in nights. If TDS is much less in nights ground water is seeping through defective sewers or joints	Provide a bypass to nearby water course in the night hours and arrange for higher capacity pump sets to nearby STP or next higher pumping station. Launch a study to locate the infiltration
6	Sewer manhole keeps sinking into ground	The sub surface soil is defective (or) the foundation has given way	Insert new manholes on each side at a reasonable distance to be away	Interconnect by a CI or DI sewer pipe laid on proper venteak piles
			Use temporary bypass pumping of sewage from upstream manhole to downstream by diesel pump sets and flexible hose till the above remedy is completed. Connect the house service connections to the upstream manhole	
7	Public do not want ventilating columns near their property	The sewers are choked and anaerobic conditions have set in resulting in foul smelling Hydrogen Sulphide gas	Pull out the column and seal the connecting pipe to the public sewer	Try to ensure sewers flow freely and not over 80 % of its depth at all times
8	Sewage pump sets require priming and take a long time	The pump is horizontal and its axis is higher than the sewage elevation in the well	Replace by wet submersible pumps	Redesign the pumping station fully
9	Sewers do not let out sewage at downstream manhole	The sewer has collapsed in between and sewage is going into the ground	Similar to the troubleshooting of item 1 above	
10	Road collapse occurs	The underground portion is hollowed because sand has been drawn into the pipe due to breakage or step displacement	safety equipments such as barricade, signs or security lights should be installed immediately around the collapsed road to prevent secondary disaster	Dig out the sewer and re-backfill or relay. As other methods, soil stabilization is required

APPENDIX B.2.2 T.V. INSPECTION REPORT

Table B2.2-1 T.V. inspection report

Book No.____________________Page No.______________________Date:_________________

Camera Direction M.H. No.____________to M.H.No.__________________Viewer_____________

<table>
<tr><td rowspan="2">District:</td><td rowspan="2">Pipe size & type:</td><td>Street</td><td>□</td><td rowspan="2">Quadrant Code</td><td rowspan="2"> 
</td></tr>
<tr><td>Easement</td><td>□</td></tr>
<tr><td>Distance:</td><td>Cleanliness of line:</td><td colspan="2">M.H.Condition:</td><td colspan="2">Grade of Line:</td></tr>
</table>

Distance Reading	Quadrant				Photo No.	Remarks	Repairs	Root Rating
	1	2	3	4				

APPENDIX B.3.1 DETAILED TROUBLESHOOTING FOR HORIZONTAL CENTRIFUGAL PUMP SETS

Table B3.1-1 Type of troubles

No	Type of Trouble	Probable causes as per conditions indexed in Table below
a.	Pump does not deliver water	1,2,3,5,6,7,9,10,15,18,21,23,26,28,29,30,31,33,40,41,42
b.	Insufficient discharge	2,3,4,5,6,7,8,9, 10,13,16,17,18, 20,21,23,24,27,28,29,30,31,33,39,40,41
c.	Insufficient pressure is developed	2,3,4,21,23,24,26,27,28,33, 39
d.	Pump loses prime after starting	22,25,28,33,37,38,49,53,54, 55,56,58
e.	Pump requires excessive power	22,25,28,33,37,38,49,53,54, 55,56,58
f.	Stuffing box leaks excessively	34,36,44,45,46,47,48,50,51, 52
g.	Gland packing has short life	11,12,34,36,44,45,47,48,49, 50, 52
h.	Bearing has short life	17,20,32,34,35,36,37,39,41, 44,48,51,54,55,56,57,58,59, 60,61,62,63
i.	Pump vibrates or is noisy at all flows	10,17,19,20,22,33,34,36,37, 38,40,41,43,45,46,47,48,51, 52,53,55,56,57,58,59,60,61,62, 63, 65
j.	Pump vibrates or is noisy at low flow	1,2,3,9,10,17,20,21,27,39
k.	Pump vibrates or is noisy at high flow	25,28
l.	Pump oscillates axially	38
m.	Coupling fails	34,36,38,60,62
n.	Pump overheats and /or seizes	1,2,3,11,12,17, 2 0,24,26,27, 31,34,36,37,38,44,45,47,48, 49,50,53,54,55,56,57,58
o.	Pump rotates in reverse direction on shutdown or after power failure or tripping	14,64

Table B3.1-2 Probable causes

No	Probable Causes
1.	Pump not fully primed
2.	Pressure at eye of impeller has fallen below vapour pressure, causing cavitation (check for clogging on suction side)
3.	Suction lift too high. (Reduce suction lift after calculating permissible suction lift from NPSHA and NPSHR)
4.	Excessive amount of air in liquid
5.	Air pocket in suction line (Check whether any point in suction line is above center line of pump, and if so, lower the line)
6.	Air leaks into suction line
7.	Air leaks into pump through stuffing boxes or mechanical seal
8.	Net opening area of foot valves is small
9.	Foot valve/strainer partially or fully clogged or silted up
10.	Suction bell mouth or foot valve insufficiently submerged
11.	Water-seal pipe clogged
12.	Seal cage improperly mounted in stuffing box, preventing sealing and allowing fluid to enter space to from the seal
13.	Circular motion in suspended suction pipe observed (The problem indicates occurrence of vortex)
14.	Foot valve leaks
15.	Flap of foot valve jammed
16.	Concentric taper in suction line causing air pocket (Replace with eccentric taper)
17.	Occurrence of vortex in intake, sump or well (Check whether all parameters for vortex-free operation are satisfied; take remedial measures)

No	Probable Causes
18.	Casing not air-tight and therefore breathing in
19.	Short bend/elbow on suction side
20.	Inadequate clearance below suction bell mouth (Raise bell mouth to achieve recommended bottom clearance for vortex-free operation)
21.	Speed too low for pump driven by diesel engine
22.	Speed too high for pump driven by diesel engine
23.	Wrong direction of rotation
24.	Total head of system higher than design head of pump
25.	Total head of system lower than design head of pump
26.	Static head higher than shut off head of pump
27.	Pump characteristics unsuitable for parallel operation of pumps
28.	Burst or leakage in pumping main
29.	Pumping main partially or fully clogged
30.	Air trapped in pumping main
31.	Malfunctioning of line valve causing partial or full closure
32.	Capacity of thrust bearing inadequate
33.	Foreign matter in impeller
34.	Misalignment

No	Probable Causes
35.	Foundations not rigid, or broken/loose foundation bolts, or supporting structural member (RCC/ structural steel beams) not rigid (Dismantle existing foundation and cast new foundation. Strengthen supporting RCC/ structural steel beams)
36.	Pump (impeller) shaft bent
37.	Rotating part rubbing on stationary part
38.	Pump shaft bearing (bush bearing or anti-friction bearing) worn
39.	Wearing rings worn
40.	Impeller damaged
41.	Impeller locking pin loose
42.	Pump shaft or transmission shaft broken
43.	Transmission shaft bent
44.	Shaft or shaft sleeves worn or scored at the packing
45.	Gland packing improperly installed
46.	Incorrect type of gland packing for operating conditions
47.	Shaft running off center because of worn bearing or misalignment
48.	Rotor out of balance, causing vibration
49.	Gland too tight, resulting in no flow of liquid to lubricate gland
50.	Failure to provide cooling liquid to water cooled stuffing boxes
51.	Excessive clearance at bottom of stuffing box between shaft and casing, causing interior packing to be forced into pump

No	Probable Causes
52.	Dirt or grit in sealing liquid, leading to scouring of shaft or shaft sleeve
53.	Excessive thrust caused by mechanical failure inside the pump or by the failure of the hydraulic balancing device, if any
54.	Excessive grease or highly viscous oil in anti- friction bearing housing or lack of cooling, causing excessive bearing temperature
55.	Lack of lubrication causing overheating and abnormal friction in anti-friction bearing, bush bearing or transmission shaft bearing
56.	Improper installation of anti-friction ring (damage during assembly, incorrect assembly of stacked bearings, use of unmatched bearings as a pair, etc)
57.	Dirt in bearings
58.	Rusting of bearing from water in housing
59.	Mechanical seal worn out
60.	Coupling bushes or rubber spider worn out or wear of coupling
61.	Base plate or frame not properly levelled
62.	Coupling unbalance
63.	Bearing loose on shaft or in housing
64.	Reflux valve (NRV) does not close tightly during shut down, after power failure or after tripping
65.	Critical speed close to normal speed of pump

Source: JICA, 2011

APPENDIX B.3.2 POSSIBLE CAUSES AND CORRECTIVE ACTIONS TO CHECK FOR PUMPS

Table B3.2-1 Corrective actions

(1) Pump won't start or run	
Float switch is not being raised high enough	Check to see if float ball is stuck. If so, remove obstacle. If required, reposition pump or remount switch in new position so it does not get stuck. Fluid level might not be high enough to engage switch. Raise float manually or add water until float is at activation height to test switch
Pump is not receiving adequate power	Check outlet to ensure that it has power. If not, replace fuse or reset breaker in fuse/breaker box. Plug pump directly into an outlet without using an extension cord. If extension cord MUST be used, ensure that it is made of adequately heavy gauge wire to support the length of cord and horsepower of pump being used. Check that wire providing power to the outlet where pump is plugged in is adequate. Pump should be plugged into an outlet that is fed by its own circuit breaker (or fuse).If circuit breaker feeds power to other outlets or appliances, use an outlet that is fed by its own breaker
Impeller is jammed with debris	Remove screen from bottom of pump and make sure no obstruction is preventing the impeller from moving freely. Remove any obstructions
Float switch is defective	Bypass the float switch. Unplug pump cord from the piggyback plug of float switch. Plug the pump's plug directly into outlet to test. If pump runs, float switch is defective. Replace float switch. (Do not leave pump plugged in too long or it will burn out)
Pump is defective	If all items above check out OK, then pump is defective and needs to be replaced
(2) Motor hums but little or no fluid is ejected from pit	
Motor is just humming but does not run	Follow diagnostics above for "Pump won't start or run"
Pump is air-locked	Drill 1/16" to 1/8" anti-airlock hole in pipe just above pump's discharge and just below check valve
Check valve is stuck or closed, or installed incorrectly	Check valve usually has an arrow on it indicating water flow. Ensure it is pointing up towards the discharge, not towards pump. Inspect to see if check valve is stuck or closed.We recommend check valves be installed horizontally in sewage applications so solids cannot settle onto the flapper valve and hold it shut
Impeller is damaged	Inspect impeller for worn or missing blades. Replace impeller if needed

Discharge pipe is partially or fully blocked	Check for blockages at discharge of pipe. If in cold area, see if pipe is frozen closed. Discharge pipe has too many 90-degree elbows which restrict flow. Using more than 3 or 4 elbows can restrict flow considerably. Consider using 45° elbows instead of 90° elbows
Impeller is jammed	Inspect impeller area of pump for debris that has jammed the impeller. Remove as needed
Suction intake screen is partly or fully blocked	Inspect suction screen at bottom for debris blocking it. Remove debris
Volute (bottom of pump) is cracked allowing water to leak out	Inspect bottom section of pump for cracks or holes that would allow water to escape
Discharge pipe is leaking	Inspect discharge pipe and joints for any location where water can leave the pipe and return to the sump pit
(3) Pump runs for a short time and ejects some fluid, but shuts off before pit is empty. (Bear in mind a few inches will remain at bottom of pit. This is normal)	
Pump is overheated and shut off by thermal overload	Be sure that pump is plugged directly into outlet. It is recommended that the outlet be fed by its own circuit breaker (or fuse). If the breaker (or fuse) sends power elsewhere, the pump may be short of voltage when it starts. Make sure proper pump has been chosen for your application. A sewage or effluent pump is designed to empty a sump, sewage or effluent pit. Using this pump where it can run for extended periods (waterfalls, pond circulation, etc.) can cause overheating
Float switch is out of adjustment	Check if pump shuts off before float ball is all the way down. If it shuts down too early, adjust float switch according to instructions in the owners' manual
Float switch is defective	If adjustment above did not resolve problem, or no adjustment is possible, replace the float switch
(4) Pump runs continuously	
Pump cord and float switch cord are plugged in separately	Plug pump cord into piggyback connector on back/side of float switch plug. Place the combination in a single receptacle of an outlet
Float switch is stuck	Inspect pit for debris that can cause the float ball to get stuck and not settle at its OFF position. Remove debris or relocate pump or switch to avoid it
Float switch is out of adjustment	For tethered style float ensure there is minimum of 5cm of cord between float ball and cord mounting bracket. Make sure cord is not so long that float can settle on floor of pit and not hang straight down
Fluid is not being discharged from pit	See item above labelled "Motor hums but little or no fluid is ejected from pit"

(5) Pump starts and stops too often	
Sewage pit or basin is very small	A very small pit or basin will simply not hold as much water. Enlarging the pit or basin (if possible) would be wise
Float switch is out of adjustment	For tethered style float ensure there is minimum of 5cm of cord between float ball and cord mounting bracket
Fluid is coming back into pit from discharge pipe	After pump has run, inspect to see if fluid is coming back into pit through the pump. If so, the check valve has failed. Replace the check valve
(6) Pump is noisy	
Discharge pipe is rattling or banging against wall and/or floor joists	Place insulating foam between pipe and wall and/or joists. Try hanging the pipe with an exhaust hanger from an auto parts store. Install a section of flexible rubber hose (like radiator hose) between the pump discharge and the discharge pipe for insulating vibrations
Check valve slams shut with a bang just after pump shuts off	Install a section of flexible rubber hose (like radiator hose) between the pump discharge and the discharge pipe for noise insulation. You may be using a pump that is higher in horsepower than you need. It may cause the water to move too fast in the pipe. After the pump shuts off, the fluid column keeps moving upward for a moment, then slams down
Pump is sucking air at end of its cycle	Adjust float switch according to the owners' manual so that it shuts off before it starts sucking air
Pump itself is vibrating	Inspect impeller for broken or missing blades, or debris stuck to blade. Clean / replace impeller or pump to rectify but also inspect sump pit to eliminate debris that could damage new impeller
(7) Fuse or circuit breaker feeding the outlet where pump is plugged in trips or blows when pump activates	
Water entered cord and/or float switch connector (especially possible if your breaker is a GFCI type breaker)	Separate pump plug from switch plug use hair dryer to dry them out. Remove cord connector from top of pump and dry out with cloth or hair dryer
Impeller is stuck or jammed with debris	Remove screen from bottom of pump and make sure nothing prevents the impeller from moving freely. Remove any obstructions
Using an extension cord or wiring to outlet which is of inadequate capacity	Check to make sure the wire supplying power to the pump is appropriate for the horsepower and amp draw of the pump in place
Shared circuit breaker (or fuse)	We recommend that the pump be plugged directly into an outlet and that the outlet is the only item being powered by the circuit breaker that feeds it. If the breaker is powering other items, the additional draw of the pump starting can pop the breaker (or blow the fuse)

Float switch is defective	Plug pump directly into outlet (without plugging into float's piggyback plug) to see if pump runs without popping breaker or fuse. If it does, but it pops fuse/breaker when plugged in through float switch, the float switch is defective. Replace float switch
Pump motor has a shorted winding	If all the items above check out OK, then the motor may be defective and it will be necessary to replace the pump

APPENDIX B.3.3 TROUBLESHOOTING IN SEWAGE PUMP STATIONS

Table B3.3-1 Troubleshooting in sewage pump stations

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Sewage pump set starts pumping and automatically trips after some time	The rated current has been exceeded because of worn out motor	Check the current drawn and compare value with that in the manual for pump set	If it exceeds rated current, stop the pump & report to competent officer
		Cavitation has changed the dynamic balance of the impeller	Check for unusual gurgling sounds from the pump volute	If so, stop the pump &report to the competent officer
		The pumping mains has been choked and there is back pressure	Verify the outlet end of the pumping main if it is a free discharge	If a pipe seems to be clogged, close the valve, remove a pipe length and check
2	Sewage pump motor heats up beyond permissible limit	Use an appropriate flap type thermometer. Do not use bare hands	Verify with the manual of the pump set	If heating is excessive, stop the pump & report to competent officer
3	Sewage pump set makes a lot of noise	Bearings have worn out or cavitation has loosened parts of impeller	Use a hand held decibel level meter and verify from 1-m distance	If noise level exceeds 80 dB, stop the pump and report to the competent officer
4	Sewage pump has continuous gland leak	A constant and steady drip is beneficial in gland packing of horizontal foot mounted pump sets, but a steady flow is a source of trouble	Most probably, the packing rope has softened and has given way	Stop the pump and rectify the same from fresh supplies
5	Sewage pump vibrates noticeably	Most probably the foundation bolts have given way or cavitation has occurred within	Install a new foundation outside the footprint of old foundation	Make an adaptor frame and remount the base plate
6	Pump seems to be drawing current, but flow meter does not record any flow	The non return valve may have tripped and discharge pressure is not able to open the flap of the non return valve. The same thing may occur with a gate valve also	The pump delivery head may be in the shut off range. This should be verified from the pump curve and delivery pressure gauge	Remove the pressure gauge, fit a standby calibrated pressure gauge and reconfirm that the pump is at the shutoff range
			Immediately shut down the pump set and arrange for opening and inspection of the non return valve and gate valve, and rectify the same. Allow the raw sewage to go through emergency bypass to identified water course	

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
7	Pump makes a humming noise when switched on, but there is no discharge	Pump may not be receiving the designated voltage	Check the voltmeter reading	If it is lower by 5% stop the pump and report to competent officer or switch over to genset if the timing is morning peak flow
		Pump delivery line may be having an air lock	Check the air valve position and release any trapped air by opening it	If the air valve is defective, replace the ball inside
		If the pump is submersible, the bottom casing may have cracked and sewage may be escaping there itself	The pump has to be switched off and physically raised above the water level and inspected	If crack is detected, take pump out of service and send it to the pump manufacturer
		The suction opening may be blocked by some sheets or rags	Stop the pump set. Use another pumpset if available	Allow the well to flood. Chances are the sheet or rag may float up and can be removed by a long pole and hook
8	Circuit breaker for the pump trips when pump is switched on	Pump motor may have shorted winding	This is to be verified by a qualified operator. If true, take the pump out of service and do not install unless it comes back fully repaired and with all correct records	

APPENDIX B.4.1 TROUBLESHOOTING IN STPs

Table B4.1-1 Manual bar screens

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Grit settles in screen chamber	Velocity of approach and velocity of exit are less than 0.6 m/s	Take a branch air line and fix it to agitate the sewage at entry and exit. This will at least help in buoyancy	Reconstruct the approach and exit channels appropriately and maintain at least 4 times the width in each location
		The flow is not entering the screen perpendicularly and forms a swirl before it		
2	Screen rods get clogged with plastic sachets, rags, sanitary napkins etc	Same causes as in 1 above	Place a flow deflector arrangement in water resistant ply upstream like the turnstile used in horse racing	
3	Hand rake rod cannot be “ploughed” freely through the full length of the screen	The rods might have been welded to a cross rod before the sewage enters the screen	Fabricate a new screen set of rods, which are individually fixed in the concrete floor and the walking platform	
4	Operator feels insecure to stand and rake	The width of platform is too small and there is no handrail behind him	Add extra width of platform with handrail at the upstream end	
5	Operator is uncomfortable in sun and rain	There is no roof	Provide a light roofing arched cover and fix appropriate light on the roof edges so that the operator is not subjected to glare	
6	Operator is not able to carry the raking bar with him while climbing up	There is no arrangement to keep the raking bar near the platform	Make arrangement for hanging the rod on the outer air side of the sidewall at waist height while standing on the platform	
7	Unusual or excessive screenings	Increase in sewage quantity or higher peak sewage flows or industrial effluents may occur	Verify flows and verify that bypass peak flows back to inlet chamber during peak hours of flow if gravity permits	If gravity does not permit and flows are very high, demand additional screen chambers

Table B4.1-2 Mechanical bar screens

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Same as items 1 and 2 above			
2	Screenings drop back into the sewage channel	The flap plate at the top requires resetting	Should not be attended by the operator. Call the equipment supplier	
3	The moving raker drops back with a loud noise	The mechanical arrangement is faulty		
4	Motor is running but raker does not move	Shear pin may be broken, or rope over the pulley may be loose, or rack & pinion are not in mesh	Should not be attended by the operator. Call the equipment supplier	
5	Marks of metal made on metal in screen rods	Alignment of stationary and moving parts are not in order and these parts have moved away		
6	Screen starts moving and suddenly the motor trips	Motor torque power is not adequate		
7	Sewage overflows screen chamber	The screen may be clogged (or) the hydraulics and channel dimensions are not matching	If choking is not the problem, refer to the design department	
8	Unusual or excessive screenings	Increase in sewage quantity or higher peak sewage flows or industrial effluents may occur	Verify flows and bypass peak flows back to inlet chamber during peak hours of flow if gravity permits	If gravity does not permit and flows are very high, demand additional screen chambers

Table B4.1-3 Detritors

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Detritors and classifiers do not bring out any grit	Sewage is flowing too fast across the detritors	Try to reduce the flow through the detritors by opening the bypass valve? and watch for improvement	If this solves the problem construct additional detritors as needed
		Grit classifier is not meshing with the grit evacuation channel floor in the case of scrapers	Try to screed the inclined floor to match the rakes	Get the channel made in SS and fix correctly
		The screw is not meshing with the curved portion in which it is moving	Change the arrangement to raker type. This is economical considering overall aspects	
		The sewage may not have grit at all	Take a sample in a beaker, allow it to settle and watch for grit load in raw sewage. If there is no grit, bypass the grit chamber and remove the mechanical equipment to stores	
2	The grit has foul smell	The grit washing mechanism is not working	Install organic return pump to lift the sewage to the top of the grit washer rake (or) screw and wash down the organics	
3	Excessive grit	Road washings, ash, or material from building sites may be entering the collection system	Add extra classifiers to the existing ones by additional SS troughs and screws	Trace the locations in collection system and rectify the connections
			Increase speed of scrapper as well as frequency of removal of grit	
4	Excessive organic matter in the grit	This can occur when the flow is small and velocity through detritors is less than design velocity	Install additional organic return pumps in classifiers	Try to recirculate outlet flows to attain the velocity
5	For all other mechanized systems refer the problem to the equipment supplier. The operator should not attempt repairs			

Table B4.1-4 Velocity controlled grit removal channels

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Grit gets washed away in the channels	Velocity varies widely between average flow and peak flow conditions	Refer the problem to the design department	
2	Grit removal facilities do not exist	Usually traveling platform with trip switches at end and vacuum pump set with hanging hoses are provided to discharge into dedicated channel along the length of grit chamber. This probably is not provided or it is not working	Do not attempt any rectification	Never enter the grit channel. Demand a mechanized grit removal system
3	The grit delivered by the grit removal vacuum system has foul smell	The system design does not permit rinsing of the grit	Construct a grit washing hydro cyclone facility	
4	Excessive organic matter in the grit	This can occur when the flow is small and velocity through detritors is less than design velocity	Reduce the number of parallel grit channels in use	Install temporary pump sets to recycle outlet flow
			Insert planks or brickwork along the length to reduce the width of flow and increase the velocity	
5	Carryover of grit	Velocity is too high and detention period is too short	Increase grit removal frequency	Add more channels or introduce equalization basin for raw sewage

Table B4.1-5 Oil & grease removal unit - gravity type

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Oil and grease floats on the surface before the downstream baffle and cannot be skimmed	The required facility of a slit pipe rotatable at the surface of the oil has not been provided	Do not try to skim by any other means. The layer is best left as it is	Arrange for spraying an insecticide mildly once a day on the scum
		The required operating platform with handrails is not provided	Demand the platform	
		The slit pipe is not rotating	Try to loosen it by blowing hot air around its housing at the ends. This can be done by using a hair drier. Stand on the outside on a ladder and not on the oil trap	If this does not work, call the equipment supplier
2	In hot summer fumes are seen above the unit	The oily scum becomes hot and starts emitting fumes	Immediately place a non flammable light roof on the unit	Install a non flammable light roof with 4.5 m headroom

Table B4.1-6 Mechanized oil & grease removal unit

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	All problems	Whatever the reasons, the operator shall not attend to the problem and shall call the equipment supplier		

Table B4.1-7 Primary clarifiers circular mechanical sludge scraper type

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Scum flows over outlet weirs	Scum baffle is not provided	Use a long wire brush to scrape out the biological growths if there is a circular walkway with handrail. If there is no walkway, do nothing	Install a circular platform with handrails on the land side. The platform shall be preferably RCC supported independent of the clarifier foundation
				Demand installation of a scum baffle all round and a scum removal arm
2	Sludge solids start floating	Choked up sludge withdrawal pipeline	If discharge is by gravity, open the valve fully and watch for sludge. If no sludge drains out, pump compressed air if a “Tee” flange joint is available. If there is no “Tee” joint, bring a sewer jet rodding machine and jet the line at mild pressure for not more than a minute and again after an hour	Even after these measures, if the sludge does not drain, divert the sewage from the clarifier, empty out by temporary diesel pump set. Then hose, inspect and rectify. Invariably, sludge pipelines are of CI or DI and they do not collapse. However, if it has collapsed, major repair is called for especially after ensuring that dewatering the groundwater is done to below the floor level of the clarifier
			If it discharges by direct suction and if no sludge drains out, pump compressed air if a “Tee” flange joint is available. If there is no “Tee” joint, bring a sewer jet rodding machine and jet the line at mild pressure for not more than a minute and again after an hour	
		Higher HRT generates gas bubbles, which reduces density of sludge solids, leads to floating of sludge lumps	1. Spray water on sludge lumps 2. Increase sludge removal frequency	
3	Sludge scraper arms do not rotate	Jamming of motor, gearbox unit (or) breakage of transmission mechanism	Check whether electrical supply is available at the motor terminals. Check the local push button switch with megger	If both the connection and switch are in order, call the equipment manufacturer

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
4	Scraper arms rotate, but the sludge coming out is merely sewage and sludge is occasional	Scraper blades have lost the squeegees at the floor level. This means the sludge is not moving towards the center for withdrawal	Guide a remote operated video camera on the sides of the wall at three or four locations. Inspect the film footage and perform repairs	
5	Excess growth of bio mass on the V notches in weirs	Indicates aerobic organisms growing in the grooves	Same procedure as in item 1 above	
6	Sludge pump runs for few minutes and stops suddenly	If it is a horizontal foot mounted centrifugal pump set, the gland packing may be too tight	Verify electrical connections, and switch off the motor. Remove the gland packing and re-fit it properly	Even after these measures, if pump does not work, call the pump set supplier
		If it is a positive displacement stator- rotor pump set, the stator and rotor might have jammed	Call the pump set supplier	
7	Sludge does not drain easily by gravity in hopper bottom tanks	Grit has entered the tanks and has choked the drain pipe of the hopper tank	Install air lift pumps on the top of tanks and evacuate the grit content periodically	Try to increase the efficiency of grit removal equipment
8	Surges occur in the settling tank overflows on the weirs	The incoming raw sewage is probably being pumped directly from the collection system	Usually settling tanks can absorb a peak flow of about 2.5 times during morning hours but if the raw sewage itself is pumped intermittently, then an equalization tank is needed	
9	Settling tank effluent is darker than raw sewage	Typically, the thickener overflow may be darker than sewage and can cause this problem	There is nothing to be done; this can be allowed to go on and will automatically be rectified after aeration tank	
10	Bubbles are noticed in the tanks and sludge spreads after the bubbles	Too much detention in the settling tank introduces septic conditions and anaerobic activity. This releases methane and hydrogen sulphide bubbles	Increase sludge removal frequency to contain the problem	Recirculate the outlet flow back to inlet to increase the flow and reduce detention

Table B4.1-8 Activated sludge plants

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Raw sewage flow is much less than design flow	This is a common problem, and it seriously affects the performance causing huge waste in the electrical energy for aeration	If the plant has been constructed in at least two parallel modules, shut down flow to one module. This applies to all units like clarifiers, aeration tanks, thickeners and digesters	Simultaneously, in the other module, remove the air diffuser facilities, motors and gearboxes in other units and store them carefully in the store. Do not disturb piping and valves
			The clarifiers may be hydraulically under loaded causing serious problems like septicity and foul odour. Try to install temporary pump set and return 100 % of treated sewage back to screen chamber	Simultaneously, verify whether it is possible to install a lower air compressor of the required air capacity calculated by pro rating the same to the flow and same head
			If possible install a new air compressor without changing the motor	If there is VFD facility for the existing air compressor, try to adjust the output prorated to the flow
			The sludge withdrawal from primary clarifier will give thin sludge and the thickener may not need separate dilution water	Consult a process design person before operating the dilution water pump set. Too much water into thick-ener is not recommended
			In the secondary clarifier, operate the return pump set as designed. The excess sludge wasting time and volume may have to be adjusted pro rata to the sewage flow versus design flow	Simultaneously, verify the MLVSS in the aeration tank. If the concentration is too low compared to the design value, throttle and reduce recirculation in the treated sewage recirculation pump set
			The digester may not be working efficiently due to smaller organic load and possibly smaller solids concentration. Do not take any action	The dewatering machines will have facilities for polyelectrolyte addition. Check the proper dosage in the lab. Do not add more polyelectrolyte than actually needed
			The dewatering machines will have facilities for polyelectrolyte addition. Check the proper dosage in the lab. Do not add more polyelectrolyte than actually needed	Construct required facilities to store the first time dewatered sludge and the required pump sets to pump it back again to the dewatering machine

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
2	Microorganisms do not develop	A balanced availability of organic material, nitrogen and phosphorous must be available otherwise organisms will not grow	In STPs of industrial clusters where the work is only in day shifts, the sewage is actually mostly urine and no night soil as the nature's call is finished by the population in their houses itself before coming to the industry. Locally available cow dung has to be dissolved in water, filtered to remove straw etc and added to aeration tank. Dosage should be determined to obtain at least 50 mg/l of BOD	Even after these measures, if microbes do not develop, supplement commercially available enzymes as per manufacturer's guidelines. Also add micro nutrients once a week. The Excel sheet for calculating the micro nutrients quantity is given in Appendix-B. Procure the chemicals, prepare a solution and add to the aeration tank slowly over an hour so that it mixes well with the tank contents. The addition is at the inlet end
			Same as above for batch type reactors like SBR	
		Toxic Material may be present in raw sewage	In case of sewage coming from one SPS, first off identify the line at inlet and divert it	First apply physico - chemical treatment to a stream carrying toxic material and then let it be allowed for further treatment
3	Raw sewage flow is much higher than design flow	This can be adjusted to about 15 %	Make sure the hydraulics is adequate	If not, bypass after grit removal
4	MLSS develops but does not survive	A peculiar problem may be the TDS of the sewage	Verify the design TDS and actual TDS	Locate the source and avoid it in the collection system
5	White coloured foaming of aeration tank	New plants usually have such problems because the sludge is young and not aged. The foam may be removed without any worries	Try to spray the treated sewage using a temporary pump set twice in a day time shift to break the foam	By adopting these measures, the problem should be controlled within a month at the maximum
			If possible attach a greenhouse nylon net to strong anchor nails on the side walls handling it carefully	
		F/M ratio is too high	Do not waste sludge from either secondary clarifier or aeration tank	
6	Dark brown foaming of aeration tank	Older plants may have such problems due to very little sludge wasted in secondary clarifier,	Increase sludge wasting and verify whether MLVSS has increased to about 70 %. If air supply is available, increase it by using the VFD	If the problem persists provide a raw sewage equalisation tank and ensure uniform raw sewage flow to the aeration tank

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
7	Greasy very dark foaming of aeration tank	Most probably, filamentous organisms such as Nocardia might have come into the MLSS	Nocardia to be checked under a microscope by a microbiologist	Check and correct oil, grease & fat in raw sewage
			Increase sludge wasting by 10 % day till the desired level of MLSS is achieved	
8	Very dark foam and mixed liquor is black	Insufficient oxygen has caused anaerobic conditions in the aeration tank	Check the DO in the aeration tank	If possible increase aeration air by VFD. If this is not available, report the matter to all including the plant in charge directly to supplement the aeration
9	MLSS concentration varies between the parallel aeration tanks	Unequal flow distribution or unequal return sludge to the aeration tanks or both can cause this problem in both surface and diffused aeration	Check the flow rates and adjust the valves of return sludge lines to each aeration tank or division weirs in flow division boxes before entry into aeration tanks	
10	Small amount of whitish foam at corners	This is actually a sign of a plant operating well		
11	Sludge rises almost all over the clarifier weir and overflows	Toxic contents in raw sewage may be causing dispersed growth bulking in aeration system	Verify F/M ratio. Most probably this would have increased to a higher value than the design value	If the aeration tank is step aeration type, send the raw sewage to the second compartment
			Verify the DO in aeration tank. This might be very low or absent	If the aeration tank is a plug flow type, try to divert the raw sewage at least about 20 % of the distance away from the inlet
			Verify the MLVSS. Its value might be very low compared to the designed value	If the tank is a complete mix tank with uniform entry of sewage all along one side, try to cut off raw sewage for one hour every shift
			Verify the raw sewage pH for any sudden drop due to acidic effluents	If the plant has facilities to add a coagulant, try to use a non ionic polyelectrolyte for some time
		Microscopic examination by a microbiologist shows a large number of filamentous organisms	Check nitrogen, phosphorous, BOD ratio and adjust N and P by adding commercial NPK fertilizers	Distribute the raw sewage along the length of aeration tanks in plug flow reactor so that initial zones can recover

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
		If the STP is not designed for denitrification and if excess oxygen is given in aeration tank, there can be nitrification of ammonia, this nitrate will be denitrified in the sludge zone of secondary clarifiers and the rising bubbles will carry over the sludge solids from the sludge layers	Check for nitrification and reduce oxygen supply to aeration tank by reducing the air output of blowers / compressors, but without affecting mixing energy requirement, which are also equally important in diffused aeration systems	Assemble 50 mm SS crib mesh with lockable clasps of size equal to cross section of launders and of cubical shape, fill with loose foam and stack along the launder at intervals to trap the solids. Periodically remove, wash and restack
			If the aeration is by surface aerators adjust the submergence to reduce the oxygen transfer	If this is not possible, follow the foam filled cribs as mentioned above
12	Sludge concentration in return sludge is low (<8,000 mg/L)	Sludge return rate is too high	Check return sludge concentration and solids level (balance) around final clarifier and settleability test	
		Filamentous growth	Check micro biota, DO, pH and nitrogen concentration; raise Do and pH, supplement nitrogen and add chlorine	
		Actinomycetes predominant	Check micro biota and dissolved iron content; if present, supplement nitrogen feed	
		Collector mechanism speed is inadequate	Adjust speed of collector mechanism	

Table B4.1-9 Biological nitrification-denitrification systems

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Nitrification does not occur	This can be due to insufficient oxygen supply, absence of required bicarbonate alkalinity and hindrance from toxic chemicals in sewage	Check for DO in the mixed liquor as it enters the secondary clarifier and find out if it is the same as in the design of the STP. If it is less, try to increase by using the VFD on the compressor	If there is still no nitirification, the problem may be elsewhere. Hence, go to the next step as given below
			Check the bicarbonate alkalinity and nitrogen ratio. The alkalinity expressed as $CaCO_3$ shall not be less than 7.5 times of nitrogen expressed as N	If the alkalinity is less, supplement it by adding sodium bicarbonate to the extent required. The quantity is to be calculated by the chemist
2	Denitrification does not occur	This is due to inadequate contact time between raw sewage, return mixed liquor and return sludge and also due to inadequate nitrification itself	Check the nitrate in the influent to and effluent from the denitrification tank and compare with the design values. If it is much lower, check the N in the raw sewage and clarifier effluent to find out the nitrification	If everything appears normal, check whether the bottom floor level mixer is functioning in the anoxic tank portion and rectify the equipment, if necessary
			Check if the BOD in raw sewage has gone up compared to design value. If this is the case, the oxygen supplied is consumed by BOD reducing micro-organisms	If this is the case, in reality there is no immediate solution in a plant already constructed and in use. The best possible solution would be to restrict the raw sewage volume proportionately

Table B4.1-10 Secondary clarifier problems

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Problems in primary clarifier sludge issues as discussed earlier are equally applicable here also			
2	Pin type of flocs in clarifier are seen and these flocs do not educe the turbidity of effluent completely	The better form of MLSS settling in clarifier is “blanket settling.” The settling flocs trap any suspended matter and pull it down along with settling. The effluent may not appear very clear	Check for nitrification and BOD removal in kg / day. If the nitrification fraction is higher then such a pin head floc formation can occur. Increase the return sludge ratio to the extent possible	If the problem persists, the only method is to add a non-ionic polymer to the mixed liquor before it enters the clarifier

Table B4.1-11 Rotating biological contactors

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Very large bio mass sloughs off from the discs all of a sudden while rotating	This can be due to pH variations and / or sudden toxic chemicals in raw sewage	Check for pH variations in raw sewage every four hours for a week. If variation is large, , try to identify the source in the collection system and correct it	If the problem persists even after taking these measures, toxic chemicals are probably entering the sewage
			Check for metals in the raw sewage and detect any unusual increase. Trace the problem to its source and correct it there	If the problem continues even after taking these measures, the only remedy is to introduce an equalization tank for raw sewage
2	Typical streaks of whitish bio mass over the discs observed frequently	The presence of hydrogen sulphide in the raw sewage and associated septicity can lead to this problem	Check the raw sewage for hydrogen sulphide odour, estimate the concentration and try to pre-aerate in the collection tank	An optional method is to introduce coarse bubble aeration in the first 25 % of the RBC drum by releasing compressed air through a pipe with perforations. This has been found to be very effective
3	Solids build up in the RBC drums	The initial BOD concentration is higher than the designed value	Check the BOD loading as per design and adjust it suitably by limiting the sewage volume	Even after this if the problem continues, verify as hereunder
			Verify whether raw sewage SS are much higher than the designed SS and try to rectify the problem at the source in the collection system	In the meantime insert coarse bubble aeration in the drum as discussed earlier
			Sometimes, a mild non ionic polyelectrolyte can be added to the influent end to precipitate coagulant from BOD load	If the problem continues in spite of these measures, introduce primary settling before RBC and take the primary sludge to aerobic digesters
4	After a period of power outage, when the RBC is re-started, it refuses to rotate, the motor creates a humming noise and the disc assembly needs an external push to set it rolling	When the power outage occurs, the biomass on the disc has water content. This water adds to the weight of the disc and initial torque of the motor is not adequate to overcome the inertia	Check alignment before trying anything else. If alignment has changed, call the equipment supplier	Ask the equipment supplier to verify and match the torque rating of the motor and the torque enforced by the wet disc assembly which is measured by the rope and weight method

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
5	Growth of snails in discs	This is an associated phenomenon of RBS systems. Strictly speaking, they do not affect the BOD removal efficiency	A simple method is to temporarily increase the RPM of the disc assembly to just about double the designed value for a few minutes at a time and use a long pole to dislodge the snails back into the sewage drum	Also, reversing the direction of feed and outlet about once a month helps build up bio mass growth to uniform weight along the length of the shaft

Table B4.1-12 Biological phosphorous and nitrogen removal

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Treated effluent contains more phosphorous than designed	The phosphorous removal occurs in the anaerobic zone. If it is not removed fully, it can cause eutrophication in receiving water bodies	Check the anaerobic zone for DO. It should be zero or less than 0.2 mg/l. If DO is high, reduce the aeration air supply to hold the DO in aeration tank to not more than 1 mg/l. This is the root cause	The air supply to aeration tank can be reduced if there is a VFD attached to the air compressor motor. If it is not there, demand for it
2	Treated effluent has low phosphorous content but the BOD is high at over 20 mg/l	This condition is possible if raw sewage BOD is higher than the design value	Check the raw sewage BOD and if needed, install supplemental air compressor to meet the extra oxygen needed for the higher BOD	Instead of supplemental air compressor, a high duty compressor can also be installed
3	Treated sewage meets phosphorous removal requirements, but the nitrogen content is much higher than required	Nitrogen removal and phosphorous removal occur in two separate zones and not together. Hence, understanding the respective problem is necessary	Confirm the raw sewage nitrogen and BOD and the air actually pumped by the air compressor to be according to design. If the air supply is less, increase it	If all parameters are as per the design, raw sewage has nitrate inhibitors. Conduct lab studies and control the source in collection system

Table B4.1-13 Facultative ponds

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Weeds grow inside the pond sewage	Weeds attract and promote growth of insects like flies, mosquitoes and so on. They can also become a nuisance as reptiles may be found hidden in the weeds	Weeds do not grow if water is more than 1 m depth. Check the outlet level and the sludge depth	If sludge depth has built up and reduced the water depth, remove the weeds
			If there are two parallel ponds, take out one pond at a time from sewage flow at start of summer and pump out the top liquid using a portable diesel pump set into the other pond	Thereafter allow the sludge to sun dry and then till it by a tractor. Leave as-is for a week and then remove the sludge taking safety precautions
2	Scum forms in the corners and insects grow over it	Scum promotes insect growth and propagation, particularly flies and mosquitoes. It can cause insect borne epidemics if not removed	Do not try to remove the scum out of the pond. Take a long thin pole and beat the scum gently so that it breaks up at the surface	Once it breaks up, the gas bubbles propping the scum are released. The scum mat will sink into the pond
3	Bunds are overgrown with weeds, small plants or even trees	The greatest risk of such growth is that someday this growth will break the bund and suddenly the sewage will flow out and fall into all wells or rivers in the zone causing a major health hazard or water borne epidemic	Physically shear off the growths. Do not pull the roots from the bund as this will loosen and break the bund. The sheared material must not fall into the pond	It is dangerous to stand on top of a tree and cut the tree branches. Use a crane and make the labourer sit inside its bucket. The cut weeds, twigs etc., can be placed into a netting tied to the bucket and taken out safely
4	Overhanging tree branches drop leaves on the pond and this causes shadow region on the pond surface	This is to be avoided because the pond requires sunlight to function and the blocking sunlight will cause septicity, and BOD removal will suffer	Identify the trees and mercilessly cut the branches overhanging the pond. Do not cut the tree as the cut roots will topple the bund	
5	Pond turns dense green in summer months	Accept it; this should not be taken as a problem	Leave it as it is and it will disappear on its own when monsoons set in	If the density is high recirculate the pond effluent by pumping
6	DO level in pond water is very low and even at mid day it does not go above 2 mg/l	This need not necessarily be a problem as long as effluent BOD is under control	Raw sewage BOD may be very low and this may cause low DO level	If DO is present in the pond effluent, do not disturb it

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
7	Oily sheen and shine slowly increases on the pond surface	This is risky. It blocks the solar heat energy from penetrating the pond, which prevents algae growth. This in turn stops oxygen production by algae, so removal of BOD from the pond is affected adversely	Check the raw sewage for oil & grease regularly. Sometimes, automobile service stations and industries will suddenly discharge waste oils into the collection system. Trace the source and control it	Demand the construction of a gravity oil & grease removal unit for raw sewage before the raw sewage is allowed into the pond This is a must
			A temporary and very effective method is to sink country wood poles around the inlet zone, tie fishing net and place straw inside this zone. The straw will absorb the oil & grease and should be left there until the oil & grease removal unit is built	

Table B4.1-14 Aerobic ponds

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Weed grows inside the pond in the liquid	Minimum 1 m liquid depth is needed to prevent weeds from growing	Check and correct the sewage depth by adding an elbow or bend to the outlet pipe to get 1 m sewage in pond. Inlet pipe may remain submerged	Simultaneously verify whether the minimum freeboard is 0.5 m. If not, the bund should be raised all round
2	Too much of algae in the pond sewage	This is inherent in aerobic ponds and cannot be avoided	As long as receiving water course has flow, algae are not a problem and the ecological system need not be disturbed	
3	Receiving water course is dry, algae die there and foul odour is present	Algae are aquatic organisms. This is a dangerous situation as algal toxins may enter soil and ground water	The immediate remedy is to bypass the aerobic pond and avoid growth of dense algae	The final remedy is to use chemical treatment instead of aerobic ponds
4	Foul odour of dead algae from ponds especially in high summer months	One possible reason is very small flow as compared to design flow, and thus very high detention time in the pond	Try to erect a temporary rock fill bund like a “coffer dam” and reduce the area of the pond pro rata to flow as compared to the design flow	The final remedy is to construct a regular cross bund, switch the flow into it and remove the rock fill

Table B4.1-15 Anaerobic ponds

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Foul odour of hydrogen sulphide (rotten egg)	This is an inbuilt mechanism when sulphate is reduced in anaerobic action	The only practical method is to use aromatic trees like Eucalyptus as live fence in two successive rows with first row at least 3 m away from the toe of the bund	
2	Oily scum with shiny appearance is floating on the pond surface	This is also an inbuilt mechanism of such ponds	Try to install a simple gravity type underflow baffle tank at the inlet and trap the oil	Engage a licensed re-refiner to collect and take away the oil periodically
3	Bubbles rise from the pond sewage and burst at the pond surface, which throws up black sludge	This is a good sign that the anaerobic system is functioning well. The end product of sulphide and methane gas lifts a column of sludge equal to its diameter and when bubble escapes to the air, the sludge disperses back into the pond	This is part and parcel of the anaerobic pond system and no action need be taken to control it. However, if the sludge in the pond has built up to leaving only about 30 cm of liquid depth, start desludging procedures as described in Section 4.1.13 Facultative ponds. If the pond is a single pond, construct a rock fill bund in the middle and proceed to desludge one after the other	

Table B4.1-16 Maturation ponds

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	These are to be dealt with similar to Section 4.1.14-Aerobic ponds			

Table B4.1-17 Land irrigation systems

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Applied sewage is ponding on land	This promotes flies, mosquitoes and may cause water borne epidemic; therefore, it should be controlled quickly	Check the ground water level. Sometimes, this may be the problem	Stop irrigating and divert the sewage to a natural drainage course
2	Sewage is running off over land instead of going in	If sodium is high, it will enter the soil and exchange the calcium and magnesium. Slowly the soil becomes hard as a rock and permeability is lost	Check the sodium content and verify whether it is within the permitted values application measured as Sodium Absorption Ratio (SAR) or Exchangeable Sodium Percentage (ESP)	If it is too high, stop irrigation for a prolonged period and wait for monsoon rains to slowly wash out the sodium by dissolution in rainwater

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
3	Irrigated crop has suddenly become weak and dies	The root zone may be flooded and air entry to soil is sealed. This creates foul odour and results in water pollution	Free up the soil by tilling it ensuring that it can breathe	Drain the stagnating sewage by cutting ditch drains
4	Nitrate concentration in ground water increases	Nitrogen is applied as nitrate and is not being taken up by plant. This can cause nitrate pollution in ground water	Check whether raw sewage nitrogen is being nitrified in the treatment plant	Verify the permissible loading rate and correct it if necessary
4	Sprinklers do not sprinkle	Suspended solids in applied sewage have blocked the pores and organisms may have grown in the sprinkler end	Removal of suspended solids is very important before application to sprinkler systems	A well constructed soil filter can help instead of a mechanized system

Table B4.1-18 Chemical treatment systems

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Flocs do not form in rapid mixer & flocculator	Flocs form from chemical reactions in rapid mixer and build up in flocculation. However, initial flocs do not develop due to organics and SS	The raw sewage does not have the required acidity or alkalinity to react with the chemicals. Check the plant O&M manual and the actual chemicals being used	The added chemical may have impurities which prevent floc formation. Examples are lime powder and commercial alum
			The added chemical may be actually different than what is indicated on the label	Carry out lab test on the chemicals
		Hydraulic shear of the raw sewage is needed in the mixer. If the tank is a circular one, vortex alone will form and not shear	Install vertical radial baffles for half the radius to break the vortex and bring up the shear	If the first stage of remedy does not work, change the tank to a square shape
2	Flocs are formed in the flash mixer but these are broken up in the flocculator	The speed of the flocculator has to be slow enough to allow the flocs to be built up to a bigger size	Take the rapid mixed sample in a glass beaker and slowly rotate it clockwise and then counter clockwise with a glass rod and watch the flocs	If the lab test proves floc can build up but the flocculator fails in the plant, then the flocculator needs to be changed
3	Chemicals settle down in the flash mixer	The mixing energy is important to keep the chemicals in suspension	Increase the speed of rapid mix impeller and watch	If this does not work, introduce additional compressed air

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
4	Flocs overflowing in the sedimentation tank	The flocs are unable to settle down	The detention time may be too short. Check the time needed by allowing a sample to settle in a glass beaker and verify the detention time in the plant	The detention time may be too short. Check the time needed by allowing a sample to settle in a glass beaker and verify the detention time in the plant
			The shape of the tank also plays an important part. Horizontal flow rectangular tanks are usually not preferred. Circular tanks with conical hopper are better	In small plants, the best arrangement will be a square shaped tank with conical hopper bottom at 60 degrees to horizontal
		The flow pattern carries over the flocs and the inlet baffle is not effective	Refer the problem to the equipment supplier	
		The flow through the unit may be much higher than what is designed	Check the design manual of the plant and rectify the same	If needed, ask for one more unit to manage the flows
5	Sludge does not dewater fully in drying beds	The water in the sludge may be a “bound water” and would need a “weighting agent” such as lime powder	Add lime powder to the wet sludge by using a paddle mixer equipment before using it on a filter bed	If it does not dewater even then, use a polyelectrolyte in addition to lime
			Other chemical such as $FeSO_4$ or $FeCl_3$ or saw dust may also apply with Lime powder	

Table B4.1-19 Treated sewage disinfection by chlorination

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	The first aid kit is either empty or it has disappeared	This is a serious problem that can happen in a plant and needs emergency measures to be adopted bypassing procedures	The plant in charge shall directly purchase a ready kit and install it	The old kit if located can be used as standby
2	The sodium hydroxide filled liquid tank is empty	This again is a major issue of a different kind and needs immediate action	Immediately stop all chlorination, close all chlorine containers and open the windows, doors, and ventilators	Call for emergency measures to fill the tank before re-commissioning the chlorination
3	here is no water in the shower	This is not an emergency, but all the same requires immediate attention	Keep at least three to four buckets of fresh water and paint the buckets in red colour to indicate it is for use in emergency situations only	Connect the shower to two different water sources so that at any one time, one of these will work
4	There is no water in the “eye rinsing wash basin”			
5	There is no residual chlorine in the chlorinated effluent	Strictly speaking, this is the desirable situation if the purpose of chlorination has been served in MPN count	Verify the MPN count of inlet to and outlet from chlorine contact tank. If the design value is not met increase the chlorine dose after lab estimation	Eventually take up re-appraisal of the chlorination system to deliver higher dosage and augment the facilities
6	There is too much chlorine in the sewage coming out of chlorine contact tank	This can be because the inlet to chlorine contact tank is not having the designed demand (or) too much chlorine is being applied to the sewage	Check the chlorine in the contact tank outlet and compare with the design value. If it is higher by 1 mg/l, reduce the chlorine dosage	Request the plant chemist to calibrate the chlorine demand every week and indicate it on a wall board for all to see
7	Testing of joints in the plumbing lines with ammonia solution swab shows white fumes	Chlorine gas when in contact with ammonia always gives whitish fumes	Immediately stop chlorination, close chlorine cylinder valves and open up all windows, doors, and ventilators. Switch on exhaust fans	Call the system supplier for a complete system check and rectification
8	Coliforms count fails to meet required standards for disinfection	Inadequate chlorination equipment capacity	Replace equipment as necessary to provide treatment based on maximum flow	
		Short circuit in chlorine contact chamber	Conduct dye test Install baffles in the chlorine contact chamber Install mixing device in chlorine contact chamber	

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
		Solids build up in contact chamber	Clean contact chamber	
		Chlorine residual is too low	Increase contact time or increase chlorine feed rate	
		High TSS	Reduce TSS in effluent	
9	Inability to maintain adequate chlorine feed rate	Malfunction or deterioration of chlorine water supply pump	Overhaul pump	
10	Inability to maintain adequate chlorine feed rate	Insufficient number of cylinders connected to the system	Connect adequate number of cylinders to system so that feed rate does not exceed the recommended withdrawal rate for cylinders	
11	Chlorinator will not feed any chlorine	Pressure reducing valve in chlorinator is dirty	Dissemble chlorinator and clean valve stem and seat. Precede valve with filter or sediment trap	

Table B4.1-20 Treated sewage disinfection by UV

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	There are no standardized methodologies in this section. Please follow accordingly as prescribed by the system supplier			

Table B4.1-21 Treated sewage disinfection by ozonation

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	There are no standardized methodologies in this section. Please follow accordingly as prescribed by the system supplier			

Table B4.1-22 Surface aerators

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Motor - high or uneven amperage	Moisture has entered the motor or winding breakdown has occurred	Have an electrician check the motor and replace with spare motor if available	Rewind the motor
		Amperage drawn is higher than the rated amperage of motor	Amperage drawn is higher than the rated amperage of motor	Call the equipment supplier
		Excessive friction and heat in motor gear	Inspect and lubricate bearings and gears	Overhaul, if needed
2	Gear reducer - bearing or gear noise	Lack of proper lubrication	Repair or replace oil pump Change oil	If problem persists, call the equipment supplier
			Remove obstruction in oil line	If problem persists, call the equipment supplier
3	Shaft coupling - unusual noise and vibration	Cracked coupling	Call equipment supplier and replace coupling; align impeller shaft	
		Loose coupling bolts/ nuts as a result of vibration	Call equipment supplier and for torque bolts, use “locking” nuts, align impeller shaft	
4	Aerator impeller - unusual noise and vibration	Loose blades	Call equipment supplier and repair torque blade bolts, use lock-washers, align impeller	
		Cracked blades	Call equipment supplier and replace torque bolts; align	

Table B4.1-23 Air blowers

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Unusual noise and vibration	Coupling misalignment	Stop the machine and realign	If difficult, call equipment supplier
		Loose nuts, bolts and screws	Stop the machine and realign	
2	Delivery air is at lower pressure than rated pressure	Bypass valve open, leaks or breaks in distribution piping	Close the valve and check the pressure instantaneously	Proceed to check leaks in pipeline by soap solution test and rectify
3	Air system - high pressure	Plugged diffusers in the aeration tanks	Check the records of pressure at each branch line and detect abnormalities	Remove, clean and refit diffusers in the abnormal line
4	Air flow rate is lower than the rated flow	Higher ambient temperature than design conditions may be the reason	Check the ambient air temperature and if it is drastically high call the equipment supplier	

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
5	System oil - low pressure	Oil level too low, oil filter dirty Valve sticks are open, incorrect oil	Drain and refill with proper oil type	
6	System oil - high pressure	Incorrect oil type	Drain and refill with proper oil type	
7	Oil discharge - low pressure	Suction lift too high Air or vapour in oil Coupling slipping on pump shaft	Purge air at filter Secure coupling	
8	Low oil temperature	Oil cooler water flow too high	Throttle water flow	
9	High oil temperature	Oil cooler water too low; incorrect oil type or insufficient oil circulation	Increase water flow Drain and refill with proper oil type Replace oil filter, check oil lines for restrictions	
10	Hot bearings	Blower speed too high Defective bearings Oil cooler water flow rate too low	Reduce speed to recommended RPM Damage: Repair or replace. Increase water flow	Call equipment supplier to check bearings for clearance, hot spots, cracks or other damage. Repair or replace Increase water flow
11	Motor doesn’t start	Overload relay tripped	Correct and reset	
12	Motor noisy	Noisy bearings	Check and lubricate	
13	Motor temperature high	Restricted ventilation Electrical abnormality	Check openings and duct work for obstruction Check for grounded or shorted coils and unbalanced voltages between phases	If in doubt, call equipment supplier

Table B4.1-24 Air distribution system

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	High, low or no indication in meters	Loose movement, out of calibration, dirt	Clean and correct defects	
2	Leakage in seals, gaskets and flex connections	Loose bolts or fittings Blown out	Tighten and or replace	
3	Pipe corrosion	Condensate	Drain traps daily, install additional traps, flush pipes, and remove standing water	
4	Sludge inside pipe	Vacuum action by reverse operation of blower	Flush pipe, install check valve on blower, repair check valve	If problem still persists, remove, clean and refit
5	Dirt in pipes	No or inefficient air filtration	Install filters, and clean filters more frequently	
6	Valves difficult to operate	Hardened grease Corrosion in valves	Remove old grease and apply seizing inhibitor, operate valves monthly, drain condensate traps daily	

Table B4.1-25 Air diffusers

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Some parts of aeration tank do not show release of air bubbles at the surface	Air is not being released from the diffusers at the floor level of the aeration tank	Loosen the joint at the walking platform and slowly lift the air drop pipe till air bubbles can be seen. This means the diffusers have choked and cannot get over the full sewage depth. Remove the drop pipe for cleaning	Another option will be in situ air purging by a portable mini air blower. This can be connected to the drop pipe by a “Tee” and closing the regular valve to purge the choked organic matter. This action can also be done routinely
			If the air system is designed for doubling the air when needed and if more than one air compressor is installed, briefly apply the air from both the compressors and purge the diffusers for about 5 minutes every hour for a few times	Most often this works very well but the system should have been designed for such an application. Please check the manual of the plant before attempting the first stage remedy. Take care that this double flow is not continued for more than five minutes in an hour

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
2	Compressor shows full design pressure, but there are no air bubbles coming out of the aeration tank	This may be a serious problem. If the pressure gauge on compressor delivery is of the Bourdon type, most probably it has gone into permanent set showing the full pressure	Switch off the compressor and verify whether the Bourdon gauge goes back to its zero position. If it does not, replace with a new one	In general, Bourdon gauges are instantaneous measurement units and not permanent reading gauges. Change these gauges to proper diaphragm gauges
			The gauges are always best installed with pressure to current converter type transducers or transmitters	Request for such a change
3	Pressure gauges are in order, compressor is in working condition but air bubbles do not rise from aeration tank	If air is not being released from anywhere in the aeration tank, it causes major leaks in transmission pipelines	If pressure gauges are available at all locations before changes of alignment of air transmission piping, try closing all these and open section after section to verify the leaky section below ground and rectify	If there is no leak, the compressor may be at fault. Check the amperage. If it is negligible then there is a mechanical problem with the compressor. Call the equipment supplier
4	Air escapes in large bursts from a few places instead of uniform diffusion all over the tank	This may be due to detachment of the air header pipe and the diffuser head at the floor; hence the bulk of air escapes at the joint location	This is a major problem and will require a team of well qualified and properly protected divers to dive and fix the problem at site while the service team is on standby at site. Do not empty the tank because growing the microbes again is not easy	
5	The entire contents appear viscous and shine like oil and air escapes at surface intermittently in large exploding bubbles	The MLSS concentration has gone out of control and become too high. They are mostly dead and cannot abstract the oxygen from the diffused air. This causes build up and sudden exploding of air bubbles	Check the MLSS and then the MLVSS. If both these values deviate very much from the design, waste fifty percent and let system recover	If this remedy also fails, there is almost surely a problem of shock loads or toxic substances coming in sewage. Check, identify locations in the collection system & rectify

Table B4.1-26 Power back up

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Sudden break/ stoppage in Air supply to Areation Tank	Power Failure	At least 20-30 % capacity of aeration blower should be back by DG (diesel generator) sets to ensure minimum air supply to aeration tank for duration of 7-8 hours	Arrange for Dual power supply (through a separate power supply grid)

Table B4.1-27 Interpretation of routine laboratory results

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	COD value is much higher than BOD	If it is only sewage, this should not be the case. However, if there are large industrial effluents from chemical manufacturing industries, this can occur	Check the N and P also and compare with the old records. If the COD is higher, report the matter to locate the source	The performance of the STP may not be up to the designed value. Focus on identifying the source and cutting it off properly
2	pH values show sudden increase or decrease	Non biodegradable organic chemicals enter into sewage i.e. wax, lignin, cellulose etc.	Pretreatment with chemical coagulation is required	
3	The colour of sewage keeps changing often			
4	The treated sewage appears turbid and cloudy but the laboratory report records BOD of less than 20 mg/l	This can be the case where the algae present in the treated sewage	Take a Whatman number-42 filter paper and filter the treated sewage into a test tube of 25 ml and check the transparency and clarity. The colour may be that of green algae but there must be clarity. If the filtrate is still turbid and strong in colour, then the pond is overloaded	
			Increase quantity of return sludge so as to increase MLSS	

Table B4.1-28 Flow measuring systems

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Bulk flow meter reading appears to be incorrect	Any mechanical equipment may go out of order at any time. The operator must have the capacity to find out the flows from other non conventional methods and compare the readings	If there is a channel of at least 10 m straight length, mark the middle 10 m and conduct a float test. Take the observed velocity at 0.8 and find out the flow	If the pump house is within the plant, find out the timings of each pump set and calculate the flow from the pump name plate
			There may be a division box for the raw sewage to the primary clarifiers. Verify the weir length and depth of flow over the weir and record the readings only in the daytime for one shift and compare with the meter reading	It is not at all advisable to go into such locations when there is no daylight because these locations are above ground level with probably no facilities for night work. An error in day shift means the same error occurs at other times also
2	Ultrasonic level sensor readings seem to be vastly different from previous recent readings	The ultrasonic level sensors actually measure the depth of the sewage water from the ultrasonic emitter. It actually measures the time from release to the return signal after bouncing back from the sewage surface, takes the average and is calibrated to the depth	Try to hold a mirror at the water surface by tying it to a long stick and note the reading given by the sensor. Actually measure the depth from the sensor to the water level if there is safe access, without getting into sewage	If the reading actually measured and that obtained with the mirror tally, then there is no problem with the sensor. If the depth shown by the sensor is different by more than 5%, the sensor must be serviced

Table B4.1-29 Septic tank and leaching systems where sewerage system is not in place

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Sewage backs up into the house	The problem is directly related to the leach pit only because a septic tank is only a flow through tank	The key point is to minimize the water used for bathing and washing clothes. This will solve many problems	
			Open the septic tank outlet chamber, pour a bucketful of water gently and watch whether it goes into leach pit immediately. If it does not flow, the leach pit has become saturated. The simplest remedy is to use the services of septage clearance vehicle and empty the septic tank periodically	Construct a fresh leach pit if there is space. If there is no space, try to clean up the old leach pit and construct an up flow filter and discharge the effluent to the street drain. Sometimes gravity will not permit this. In such cases, use a septage vehicle, which is the only answer to this problem

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
2	Foul smell comes out of the ventilating cowl	This is the result of the process in the septic tank, and cannot be stopped, but it can be treated	Spray the mosquito net of the cowl with bleaching powder solution daily and keep it wet	If the problem continues, a biological filter consisting of gunny cloth of coir wetted with bleaching powder solution may be tied
			If space is available construct a smaller septic tank and up flow filter only for toilets and then allow it into the main septic tank	If the problem continues, the only solution is to frequently use the septage clearance vehicle

Table B4.1-30 Sequencing batch reactors (SBR)

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Raw sewage flow is less than the design flow	This is a usual problem in some cases in the initial period	If the flow is adequate to run one of the modules, use that module alone and leave the other one unused	If the flow is small even for this, use the SBR tank as an ASP for 20 hours, then stop the flow and decant. During this time divert the flow to the other module. Once decanting is completed, start that module and pump the raw sewage from the temporary module to it
			If the air compressor output air volume is too much, use the VFD to reduce the same to match the raw sewage flow	Always ensure that the residual DO in the aeration is not less than 1 mg/l during aeration
2	Raw sewage flow is higher than the design flow	This type of problem is very rare	Try to use all modules simultaneously except one and run the plant in continuous mode and decanting mode as above	The spare module will be used to receive the raw sewage when the other modules are in decanting mode and then sewage is pumped
	Almost all other issues discussed under ASP shall apply here also			

Table B4.1-31 Moving biofilm bed reactors (MBBR)

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Raw sewage flow is less than the design flow	Almost all other issues discussed under SBR is applicable here		
2	Raw sewage flow is higher than the design flow	Almost all other issues discussed under SBR is applicable here		
3	Almost all the media are floating at the liquid surface only and do not mix fully into the depth of reactor	This happens in some tank geometries and because the specific gravity of the media is just about the same as that of water	Mixing equipment are available as sidewall mounted facilities which bring about a circular motion of the media in vertical plane. These can be simply fixed on a steel post and anchored to the concrete base. This is similar to erecting a submersible pump set. If anchoring facility is not available, hire a qualified diver from the fire service.	
	Media floats in air/ surrounding area with or without foam	Gas or air trapped in media reduces its density	Gas or air trapped in media reduces its density	Increase height of side walls

Table B4.1-32 Membrane bio reactors (MBR)

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Raw sewage flow is less than the design flow	Almost all other issues discussed under SBR is applicable here		
2	Raw sewage flow is higher than the design flow	Almost all other issues discussed under SBR is applicable here		
3	Membrane permeate volume is reducing slowly	In general, this is because the MLSS cannot be filtered by the membranes. The problem may occur in both suction type and pressure feed types If sludge bulking occurs, it is due to the filamentous organisms. Usually at high MLSS of 10,000 mg/l filamentous organisms do not create any problems	Look under the microscope for organisms like Nocardia or Sphaerotilus natans-like filamentous bacteria. Get assistance from a qualified microbiologist. If these are detected, do not panic. Take a sample in a one litre glass jar and observe the settling. If sludge settles to 30 % in half hour, it is still OK	If it does not settle and the jar appears cloudy even after an hour, then there is a need to intervene. The first step is to flush the membranes if these are fixed (or) to remove, clean and rinse if these are removable. In the mean-time, identify the bulking reasons as stated under ASP and try to solve the problem. Do not allow the problem to continue. It will choke the membrane
4	Membrane permeate often brings out microbial suspended solids	May occur when some membranes give way and the microbes escape through it at higher pressure differences	Try to methodically isolate each module by isolating valves and study the problem	After identifying the module, remove it and get it duly serviced before replacing it on line
	Almost all other issues discussed under ASP is applicable			

APPENDIX B.4.2 OPERATIONAL PARAMETERS

4.2.1 PARAMETERS

Typical values of loading parameters for primary and secondary clarifiers and various activated sludge modifications commonly used in India are furnished in Table B4.2-1 and Table B4.2-2, respectively.

Table B4.2-1 Table parameters for Clarifiers

Type of Settling		Overflow rate, $m^3/m^2/day$		Overflow rate, $m^3/m^2/day$		Side water depth, m	Weir loading, $m^3/m/day$
		Average	Peak	Average	Peak	Average	Average
Primary Clarifiers	Primary Settling only	25 - 30	50 - 60	---	---	≥ 2.5 - 3.5	125
	Followed by secondary treatment	35 - 50	80 - 120	---	---	≥2.5 - 3.5	125
	With activated sludge return	25 - 35	50 - 60	---	---	≥3.5 - 4.5	125
Secondary Clarifiers	Secondary settling for activated sludge	15 - 35	40 - 50	70 - 140	210	≥3.0 to 3.5	185
	Secondary settling for extended aeration	8 - 15	25 - 35	25 - 120	170	≥3.0 to 4.0	185

Note: Where the mechanized aerobic treatment is used after UASB reactor, the settling tank design shall be based on conventional activated sludge process as above.

Table B4.2-2 Parameters of Activated sludge systems

Process Type	Flow Regime	MLSS	MLVSS/ MLSS	F/M	HRT	θ_C	QR/Q	BOD removal	kg O_2/ kg BOD removed
		mg/L	ratio	Day-1	hrs	days	ratio	%	ratio
Conventional	Plug flow	1,500-3,000	0.8	0.3-0.4	4-6	5-8	0.25-0.5	85-92	0.8-1.0
Complete mix	Complete mix	3,000-4,000	0.8	0.3-0.5	4-5	5-8	0.25-0.8	85-92	0.8-1.0
Extended aeration	Complete mix	3,000-5,000	0.6	0.1-0.18	12-24	10-25	0.5-1.0	95-98	1.0-1.2

4.2.2 LOADING RATE

a. HRT (Hydraulic retention time)

The loading rate expresses the rate at which the sewage is applied in the aeration tank. A loading parameter that has been developed empirically over the years is the hydraulic retention time (HRT), θ, day.

$$\theta\,(\text{day}) = \frac{V}{Q} \qquad \text{(B4.1)}$$

Where,

V : Volume of aeration tank, m^3, and

Q : Sewage inflow, m^3/day

Another empirical loading parameter is volumetric organic loading which is defined as the BOD applied per unit volume of aeration tank, per day.

b. Specific substrate utilization rate

A rational loading parameter which has found wider acceptance and is preferred, is specific substrate utilization rate, U, per day which is defined as:

$$U\ (day^{-1}) = \frac{Q(S_0 - S)}{VX} \qquad (B4.2)$$

Where,

S_o: Influent organic matter as BOD_5, g/m^3

S : Effluent organic matter as BOD_5, g/m^3

Q : Sewage inflow, m^3/day

V : Volume of aeration tank, m^3

X : MLSS conc. in aeration tank, g/m^3

c. SRT (Sludge retention time)

A similar loading parameter is mean cell residence time or sludge retention time (SRT), θ_c day:

$$\theta_c\ (day) = \frac{VX}{Q_w X_s} \qquad (B4.3)$$

Where,

V: Volume of aeration tank, m^3

X: MLSS concentration in aeration tank, g/m^3

Qw: Waste activated sludge rate, m^3/d

Xs: MLSS conc. in waste activated sludge from secondary settling tank, g/m^3

d. F/M ratio

If the value of S is small compared to S_o, which is often the case for activated sludge systems treating municipal sewage, U may also be expressed as Food applied to Microorganism ratio.

$$F/M = QS_0 / XV \qquad (B4.4)$$

Where,

Q : Sewage inflow, m^3/day

S_o : Influent organic matter as BOD_5, g/m^3

V : Volume of aeration tank, m^3

X : MLSS concentration in aeration tank, g/m^3

4.2.3 OXYGEN REQUIREMENTS

Oxygen is required in the activated sludge process for the oxidation of a part of the influent organic matter and also for the endogenous respiration of the micro-organisms in the system. The total oxygen requirement of the process may be formulated as herein:

$$O_2 \text{ required (g/d)} = (Q(S_0 - S)/f) - 1.42\Delta_X \quad \text{(B4.5)}$$

Where,

f : Ratio of BOD to ultimate BOD

1.42 : Oxygen demand of biomass, g/g

Δ X is biological sludge produced per day.

$\Delta X = Q \times Y \text{ observed} \times (S_o - S)$

Yobs = Y/(1+Kd×θC)

Where Y is 0.5

Kd is 0.06

The formula does not allow for nitrification but allows only for carbonaceous BOD removal. The extra theoretical oxygen requirement for nitrification is 4.56 kg O_2/per kg NH_3 -N oxidized to NO_3 - N.

The total oxygen requirements per kg BOD, removed for different activated sludge processes are given in Table B4.2-2. The amount of oxygen required for a particular process will increase within the range shown in the table as the F/M value decreases.

4.2.4 OXYGEN TRANSFER CAPACITY

Aerators are rated based on the amount of oxygen they can transfer to tap water under standard conditions of 20°C, 760 mm Hg barometric pressure and zero DO. The oxygen transfer capacity under field conditions can be calculated from the standard oxygen transfer capacity by the formula:

$$N = \frac{N_s(C_s - C_L) \times 1.024^{(T-20)}\alpha}{9.17} \quad \text{(B4.6)}$$

Where,

N : Oxygen transferred under field conditions, kg O_2/kW/hr

N_s : Oxygen transfer capacity under standard conditions, kg O_2/kW/hr

C_s : Dissolved oxygen saturation value for sewage at operating temperature, mg/L

C_L : Operation DO level in aeration tank usually 1 to 2 mg/L

T : Temperature, °C

α: Correction factor for oxygen transfer for sewage, usually 0.8 to 0.85

Values of Cs is calculated by arriving at the dissolved oxygen saturation value for tap water at the operating temperature and altitude as in Table B4.2-3 and Table B4.2-4 and then multiply it by a factor which is usually 0.95 for domestic sewage without undue industrial effluents and with TDS in the normal range of 1,200 to 1,500 mg/L.

Table B4.2-3 DO saturation vs. temperature in Celsius in tap water at MSL

The relationship between temperature and oxygen solubility	
Temperature (degree C)	Oxygen solubility (mg/L)
0	14.6
5	12.8
10	11.3
15	10.2
20	9.2
25	8.6
30	7.5
35	6.9
40	6.4
100 (boiling)	0.0

Table B4.2-4 DO correction factor for altitudes

Altitude (feet)	Altitude (meters)	Factor
0	0	1
500	152	0.98
1000	305	0.96
1500	457	0.95
2000	610	0.93
2500	762	0.91
3000	914	0.89
3500	1067	0.88
4000	1219	0.86
4500	1372	0.84
5000	1524	0.82
5500	1676	0.81
6000	1829	0.80

4.2.5 SLUDGE RECIRCULATION RATE

The MLSS concentration in the aeration tank is controlled by the sludge recirculation rate and the sludge settle ability and thickening in the secondary sedimentation tank.

$$\frac{Q_R}{Q} = \frac{X}{X_s - X} \qquad \text{(B4.7)}$$

Where,

Q_R : Sludge recirculation rate, m^3/d

Q: Sewage inflow, m^3/day

X: MLSS concentration in aeration tank, g/m^3

X_s: MLSS conc. in waste activated sludge from secondary settling tank, g/m^3

4.2.6 EXCESS SLUDGE WASTING

Excess sludge = (A/(0.6 to 0.8)) + B

A is calculated by the following equation and 0.6 to be used for extended aeration and 0.8 is used for conventional activated sludge.

$A = Q \times Yobs\ (S_o - S)a$

$Yobs = Y/(1+Kd \times \theta_C)$

Where Y is 0.5

kd is 0.06

B = Q×inert TSS removal

Inert TSS = Influent TSS – Influent VSS

TSS removal in primary settling tank is 60 percent.

Inert SS removal in primary settling tank is 80-90 percent.

VSS removal in primary settling tank is 20-40 percent.

θ_C is from Figure B4.2-1 for the lowest operating temperature.

Excess sludge in kg/day = Yobs × BOD_{inlet} × Flow MLD

Calculate excess sludge kg/day from the thumb rule in this section.
Adopt the higher value.

Excess sludge volume (m^3/day)

= Excess wasted (kg/day) × 1000/MLSS in clarifier underflow

The SRT as a function of aeration basin temperature for 90-95% BOD removal as in Figure B4.2-1

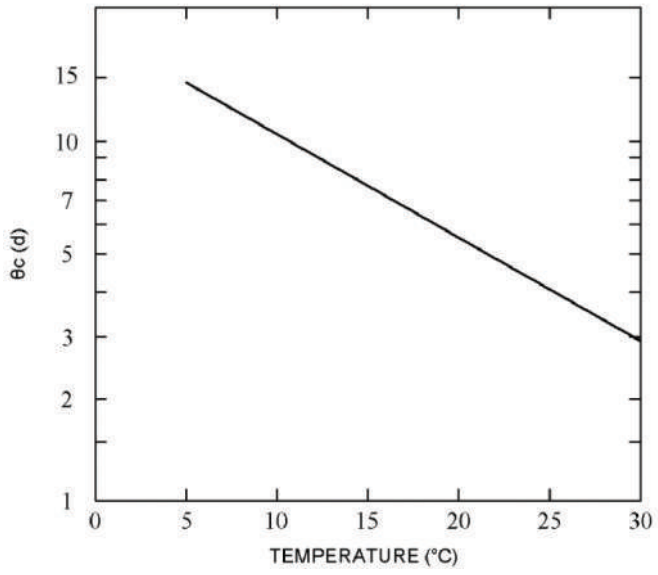


Figure B4.2-1 SRT as a function of aeration basin temperature for 90-95% BOD removal

APPENDIX B.4.3 CALCULATIONS

4.3.1 EXTENDED AERATION ACTIVATED SLUDGE TANK

An extended aeration activated sludge tank has the following dimensions for treating the waste with following characteristics;

Length	= 60 m
Width	= 20 m
Water depth	=5 m
Flow	=7,500 m^3/day
Influent BOD	=200 mg/L
Effluent BOD	=10 mg/L
Influent SS	=200 mg/L
Influent VSS	=150 mg/L
MLSS	=4,000 mg/L
SV_{30}	=400 mL
MLVSS	=2,800 mg/L
Yobs	=0.4 mg VSS/ mg BOD
Kd	=0.04 day-1

Determine:

a. Hydraulic retention time, day
b. BOD loading, kg/day
c. BOD volumetric loading, kg/m^3.day
d. Microorganisms in aeration tank, kg
e. F/M ratio, kg/kg.day
f. SVI, mL/g
g. Excess sludge generation, kg/day
h. Excess sludge concentration, mg/L
i. Excess sludge volume, m^3/day
j. SRT, day
k. Return sludge flow rate, m^3/day
l. Oxygen requirement, kg/day

Solution:

$$\text{a. Hydraulic retention Time (days)} = \frac{\text{volume}}{\text{Discharge}}$$

$$\text{Volume} = 60(\text{m}) \times 20(\text{m}) \times 5(\text{m}) = 6{,}000(\text{m}^3)$$

$$\text{HRT} = \frac{6{,}000(\text{m}^3)}{7{,}500(\text{m}^3/\text{day})}$$

$$= 0.8(\text{days}) = 19.2(\text{hours})$$

$$b.\ BOD\ Loading\ (kg/day) = BOD\ (kg/m^3) \times Flow(m^3/day)$$
$$= 200(mg/L) \times \frac{1{,}000\ (L)}{1(m^3)} \times \frac{1(kg)}{1{,}000{,}000(mg)} \times 7{,}500(m^3/day)$$
$$= 1{,}500(kg/day)$$

$$c.\ \text{BOD Volumetric Loading (kg / m}^3\text{ .day)} = \frac{\text{BOD Load (kg / day)}}{\text{Volume (m}^3\text{)}}$$
$$= \frac{1{,}500\ \text{(kg / day)}}{6{,}000\ \text{(m}^3\text{)}}$$
$$= 0.25\ \text{(kg / m}^3\text{ .day)}$$

$$d.\ \text{Microorganisms in Aeration Tank (Kg) = Volume (m}^3\text{) x MLSS(kg/m}^3\text{)}$$
$$= 6{,}000(\text{m}^3) \text{ x } 2{,}800(\text{mg/L}) \text{ x } \frac{1{,}000\ \text{L}}{1\text{m}^3} \text{ x } \frac{1\text{kg}}{1{,}000{,}000\text{mg}}$$
$$= 16{,}800(\text{kg})$$

$$e.\ \text{F/M Ratio (kg / kg .day)} = \frac{\text{Flow x BOD}}{\text{volume x MLVSS}}$$
$$= \frac{\text{BOD Load(kg / day)}}{\text{Microorganisms in Aeration Tank(kg)}}$$
$$= \frac{1{,}500(\text{kg / day})}{16{,}800(\text{kg})} = 0.089(\text{kg / kg .day})$$

$$f.\ \text{SVI(ml / g)} = \frac{\text{Sludge Settled (ml / L)}}{\text{MLSS (g/L)}}$$
$$= \frac{400\ \text{(ml)}}{4\text{(g)}}$$
$$= 100\ \text{(ml /g)}$$

$$g.\ \text{Excess Sludge Generation = Px (Sskg / day)}$$
$$= \text{Yobs x Q x } (S_0\text{-S}) + \text{Q x (TSS}_{in} - \text{VSS}_{in})$$
$$= 0.4(\text{VSSkg / BODkg}) \text{ x } 7{,}500(\text{m}^3\text{ / d}) \text{ x } (200\text{-}10)(\text{mg / L}) \text{ x } \frac{1{,}000\ \text{L}}{1\text{m}^3} \text{ x } \frac{1\text{kg}}{1{,}000{,}000\text{mg}}$$
$$+ 7{,}500(\text{m}^3\text{ / d}) \text{ x } (200\text{-}150)(\text{mg / L}) \text{ x } \frac{1{,}000\ \text{L}}{1\text{m}^3} \text{ x } \frac{1\text{kg}}{1{,}000{,}000\text{mg}}$$
$$= 570\ \text{(kg/ day)} + 375\ \text{(kg / day)}$$
$$= 945\ \text{(kg / day)}$$

$$h.\ \text{Excess Sludge Concentration (mg / L)} = \frac{1{,}000{,}000}{\text{SVI}}$$
$$= \frac{1{,}000{,}000}{100}$$
$$= 10{,}000(\text{mg / L})$$

$$\text{l. Excess Sludge Volume}(m^3/day) = \frac{\text{Excess sludge (kg / day)}}{\text{Sludge Concentration (kg / m}^3)}$$

$$= \frac{\text{Excess sludge (kg / day)}}{10{,}000(\text{mg /L}) \times \frac{1{,}000\text{L}}{1\text{m}^3} \times \frac{1\text{kg}}{1{,}000{,}000\text{mg}}}$$

$$= 94.5(m^3/day)$$

$$\text{j. SRT(day)} = \frac{\text{Microorganisms in Aeration Tank(kg)}}{\textit{Microorganism Wasted (kg / day)}} = \frac{16{,}800\ (\text{kg})}{570\ (\text{kg/day})} = 29.4\text{days}$$

$$= \frac{\text{Total MLSS in organisms in Aeration Tank (kg)}}{\textit{Total Sludge Wasted (kg / day)}}$$

$$= \frac{6{,}000(m^3) \times 4{,}000(\text{mg/L}) \times \frac{1{,}000\text{L}}{1\text{m}^3} \times \frac{1\text{kg}}{1{,}000{,}000\text{mg}}}{945\ (\text{kg/day})} = 25.3\text{days}$$

$$k.\ \text{Return Sludge Flow Rate} = Q_r$$

$$= \frac{V_{30} \times Q}{1{,}000(ml) - V_{30}}$$

$$= \frac{400(ml) \times 7{,}500(m^3/day)}{1{,}000(ml) - 400(ml)}$$

$$= 5{,}000(m^3/day)$$

$$l.\ \text{Oxygen Requirement}\ (kgO_2/day) = 1.47 \times \textit{mass of BOD removed}(kg/day) - 1.42 \times \textit{mass of organisms wasted}(kg/day)$$

$$= 1.47 \times 7{,}500(m^3/day) \times (200 - 10)(mg/L) \times \frac{1{,}000L}{1m^3} \times \frac{1kg}{1{,}000{,}000mg} - 1.42 \times 570(kg/day)$$

$$= 2{,}094(kg/day) - 809(kg/day)$$

$$= 1{,}285(kgO_2/day)$$

4.3.2 PRIMARY SEDIMENTATION TANK

Characteristics of influent to and effluent from primary sedimentation tanks are as follows;

Flow rate =10,000 m^3/ day
Influent BOD = 200 mg/L
Influent SS = 300 mg/L
Effluent BOD = 140 mg/L
Effluent SS = 100 mg/L

Find:

a. The BOD removal efficiency of the primary sedimentation tank, %

b. SS removal efficiency of the primary sedimentation tank, %

c. Dry sludge generated, kg/day

d. Volume of sludge generated, m^3/day if sludge concentration is 40,000 mg/L.

Solution:

$$\text{a. BOD Removal Efficiency (\%)} = \frac{(\text{Influent BOD} - \text{Effluent BOD}) \times 100\%}{\text{Influent BOD}}$$

$$= \frac{(200-140)\times 100}{200}$$

$$= 30\ (\%)$$

$$\text{b. SS Removal Efficiency (\%)} = \frac{(\text{Influent SS} - \text{Effluent SS}) \times 100\%}{\text{Influent SS}}$$

$$= \frac{(300-100)\times 100}{300}$$

$$= 66\ (\%)$$

$$\text{c. Sludge Solid generated (kg / day)} = \text{Flow } (m^3 / \text{day}) \times (TSS_{in} - TSS_{out})(\text{mg / L})$$

$$= 10{,}000(m^3 / \text{day}) \times (300-100)(\text{mg/L}) \times \frac{1{,}000\ \text{L}}{1m^3} \times \frac{1\text{kg}}{1{,}000{,}000\text{mg}}$$

$$= 2{,}000\ (\text{kg / day})$$

$$\text{d. Volume of Sludge generated} = \frac{\text{Sludge (kg / day)}}{\text{Concentration of sludge } (\text{kg} / m^3)}$$

$$= \frac{2{,}000\ (\text{kg / day})}{40{,}000(\text{mg/L}) \times \frac{1{,}000\ \text{L}}{1m^3} \times \frac{1\text{kg}}{1{,}000{,}000\text{mg}}}$$

$$= 50\ (m^3 / \text{day})$$

4.3.3 CIRCULAR SECONDARY SEDIMENTATION TANK

A circular secondary sedimentation tank has the following dimensions for treating the waste with following characteristics;

Diameter	=20m
Depth	=3.5m
Inflow	=10,000 m3/day
Return sludge flow	=5,000 m3/day
MLSS	=4,000 mg/L

Find:

a. Surface overflow rate,
b. Detention time,
c. Solids loading rate, and
d. Weir overflow rate.

Solution:

$$a.\,Surface\,Overflow\,Rate\,(day) = \frac{Flow(m^3/day)}{Surface\,Area\,(m^2)}$$
$$= \frac{10{,}000(m^3/day)}{0.785 \times 20 \times 20(m^2)} = 31.8 m^3/m^2.day$$

$$b.Detention Time(day) = \frac{Volume(m^3)}{Flow(m^3/day)}$$
$$= \frac{0.785 \times 20 \times 20 \times 3.5\,(m^3)}{10{,}000(m^3/day)}$$
$$= 0.1099 \times 24 = 2.63(hrs)$$

$$c.\,Solids\,Loading\,Rate(kg/m^2.day) = \frac{(Inflow + Return\,Sludge\,Flow)(m^3/day) \times MLSS(mg/L)}{Surface\,Area(m^2)}$$
$$= \frac{(10{,}000 + 5{,}000)(m^3/day) \times 4{,}000(mg/L) \times \frac{1{,}000L}{1m^3} \times \frac{1kg}{1{,}000{,}000mg}}{0.785 \times 20 \times 20(m^2)}$$
$$= 191(kg/m^2.day)$$

$$d.\,Weir\,Over\,Rate\,(m^3/m.day) = \frac{Flow(m^3/day)}{Weir\,Length\,(m)}$$
$$= \frac{10{,}000\,(m^3/day)}{3.14 \times 20\,(m)}$$
$$= 159\,(m^3/m.day)$$

APPENDIX B.5.1 TROUBLESHOOTING IN SLUDGE TREATMENT FACILITIES

Table B5.1-1 Sludge thickening by gravity thickeners

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Typical septic odour of hydrogen sulphide	Any thickener will invariably produce a typical odour. Do not try to disturb the system because of this alone	Check the per day total of sludge volumes and dilution water pumped into the thickener. Compare with per day total of sludge withdrawn and thickener overflow. Check for volume balance If the outlet is lesser, sludge stays longer and is likely to choke and become septic. Withdraw more sludge	If this fails to solve the problem, investigate a sludge flocculation system like the picket fence, etc. This may have given way below the liquid level. If the ampere of the motor is very low compared to design consumption, call the equipment supplier to attend to the system. Do not attempt it by yourself
2	Thickened sludge is not what is designed for	Typically a minimum detention time is needed for sludge solids to break free of bound water and thicken at the bottom. If this is not occurring, the thickened sludge will be very weak	Check volumes of sludge and dilution water entering the tank from their flow meters. Reduce the flows so they do not exceed design values. Check flocculator also	Even after this, if the problem persists, the reason lies with the type of sludge and not the thickener. Proceed to clarifier sludge sections
3	Biological growth over the outlet weir surfaces becomes very dense	This is related to the escape velocity over the weir length and temperature conditions. Do not alter the process conditions if they are as per the design	The simplest remedy is a daily scrubbing of the weir surface by a wire brush and a long handle while walking along the outer platform	Even after this, if the problem persists, remove the V notch plate and level the weirs as shown in Part-A , Figure 5-29
4	Sludge solids are overflowing the outlet weirs	As long as the inflow and outflow rates are not exceeding the design values, this problem has nothing to do with the thickener. Do not alter the process	Proceed to the sections on clarifiers. Sludge from secondary clarifier may be very loose and not settling down. Follow the remedy	Even after this, if the problem continues, add polyelectrolyte to the thickener feed well temporarily
5	Drive motor trips often	Too much of sludge at the bottom or a foreign object is obstructing the free movement of the flocculator paddles	Try increasing the sludge withdrawal frequency temporarily for a day. Most probably this will solve the problem	Even after this, if the problem continues, check the gearbox visually for any broken teeth and call the equipment supplier
6	Chocking of sludge pump	Top Layer may become dry as a result of direct sunlight	Roof may be provided to protect from direct sunlight	

Table B5.1-2 Anaerobic sludge digesters

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
This is an identified high risk unit operation for any person trying to look into this unit or enter it. Sometimes strobe lights are installed inside the digester to light up the inside so that it can be seen through a fixed glass plate on the cover slab and viewed from outside. This shall not be allowed, as a simple spark at the cable terminal can blow up the digester by igniting the methane gas inside it. All investigations of digester performance should be made indirectly by observing the performance parameters and never by directly entering the digester. Persons smoking near the digester or while standing near the top dome are likely to cause severe accident. There is at least one case of the operator and the dome getting blown up because of smoking. In actual practice, there is not much an operator can do to correct the digester mechanism if it is not functioning because work on such equipment is a highly specialized task requiring high skills in explosive zones. The operator can attend only to the pump and motor of externally circulated sludge mixing type digesters, in which standard horizontal foot mounted centrifugal pumps are coupled to motors. All other types of equipment are prohibited from being repaired by the operator and shall be attended to only by the equipment supplier or his service personnel.Hence troubleshooting of digesters will be confined only to process control in this section				
1	Gas production is less than the designed output	Gas production is a function of the VSS and detention time and mixing efficiency in the digester. Measure the VSS in feed sludge in the lab and verify loading rate from feed flow. Compare with design values	If the feed VSS is too low, then gas production will surely be very small. If the feed VSS is too high, then also gas production will suffer. First check the value of VSS	If the conditions are as per the design, it is a clear case of mixing system failure. Call the equipment supplier. Do not correct it except in case of externally re-circulated pumped sludge
		Sometimes, the pH of the digester may be less due to too much of acidification. This can be checked in the lab and compared with past records	Raising the pH to 6.8 - 7.2 is required. Though lime solution is the easier option, the use of sodium hydroxide is preferable because it does not create problems of precipitates in the digester or the sludge pipelines	Even after these measures, if the problem persists, the reason is not with the process, but with either the mixing equipment in the digester or the sludge quality coming out of the clarifiers. First check on the sludge quality as per earlier sections. If the quality is in order, call the equipment supplier to inspect the mixing equipment and bring it to maximum efficiency. This shall not be attempted by operator
			The feeding of the solution shall be by a solution tank and acid-alkali proof dosing pump mounted at ground level. The delivery pipeline shall be thick walled UPVC pipeline discharging into the sludge suction sump	

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
2		Sometimes there is an auto toxicity problem when high TDS waters are used by the habitation. The sulphate in the water gets into sewage. This gets into digester liquid. The sulphate reduces to sulphide. This is partly converted to hydrogen sulphide gas. The unreacted sulphide is toxic to digesters in the range 50 mg/l in dispersed sludge and 250 mg/l in granular sludge. In digesters, it is usually dispersed sludge	Check the sulphate content of the digester feed and digested outlet. Estimate the sulphide produced as one third of the sulphate. Estimate 40 % of this value as unreacted sulphide. Also estimate sulphide in the digested liquid by titration in the laboratory. Consult a process specialist on this further to establish sulphide toxicity as the reason	The way to reduce this toxicity is to prevent the sulphates from getting reduced to sulphide in the first place, but this is not possible inside a digester. A higher degree of mixing usually expels the hydrogen sulphide gas faster and thus, promotes more formation in the digester liquid. This reduces the unreacted sulphide remaining in the digester
3	Foul or sour odour	Usually, a well digested sludge does not smell offensive. If the digested sludge smells sour and foul, the digester has probably become sour and the pH may have dropped	Follow the procedure for raising the pH of the digester by lime or preferable sodium hydroxide as described earlier	
4	Smell of hydrogen sulphide when walking around the base of the fixed dome on the digester	Apply soap solution to all piping joints to verify any leaky joints or cracked pipes. It can also be the digester sidewalls, which are above the sludge level, but usually this is not the case	Erect a sign board in local language and all familiar languages that gas is leaking and persons shall not go to the top of digesters	Do not try to fix the problem by yourself. Call the equipment supplier to attend to it
5	Smell of hydrogen sulphide when walking around the base of the floating dome on the digester	Floating dome covers are usually fabricated from steel or synthetic materials. The joints are the sources of the leak. It can also be the digester sidewalls which are above the sludge level but usually this is not the case		

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
6	Smell of hydrogen sulphide when walking around the base of the inflatable gas holder on the digester	Usually these are inflatable gas balloons made of synthetic material and are of multi layered construction. Unless there is an external puncture, these do not leak. The actual leak may occur at the base where the gas cover is jointed with the digester which again is through a piping. Thus, the fastening around the joint piping should be checked	The simple soap solution test will help in identifying the leak. If this is the case, the fasteners are to be fixed	Do not try to fix the problem by yourself. Call the equipment supplier to attend to it
7	Floating gas dome on the digester is not truly vertical but is tilted	The holding down weights on the rim are not properly adjusted	Try small adjustments at a time by adding or removing the weights	Once it becomes vertical, record the work in the site register
8	Gas pressure in the gas line from digester is higher than the design value	Gas is not being withdrawn regularly or gas production is more than the design	Use the flame trap to release and burn off the required volume of the gas	
9	Gas pressure in the gas dome is less than the design value	Gas production is not adequate	Take no action but attend to the sludge section as discussed earlier	
10	Mixing systems	Get an authorized agency to inspect, service and leave a report at regular intervals which can be monthly intervals		

Table B5.1-3 Mechanical sludge dewatering devices

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Metallic noise in moving parts	May be due to worn out bearings or absence of lubrication	Lubricate moving parts	Refer bearing problems to equipment supplier

Table B5.1-4 Sludge drying beds

No.	Troubles / Problems	Likely causes	First stage remedies	Second stage remedies
1	Fires occur in drying beds	This is due to methane gas in high summer months ignited by a spark from an electrical line or due to somebody smoking nearby	This is due to methane gas in high summer months ignited by a spark from an electrical line or due to somebody smoking nearby	Erect a warning board that cell phones should be switched off for a distance of about 10 m from the edges of the drying beds
2	Wet sludge is ponding for a long time and does not filter	The drying bed might have choked or the sludge applied without digestion	Cut off the sludge flow to the bed and allow it to filter through slowly. Till it lightly by a long boom crane from all sides and restart	If the F/M ratio is higher than 0.2 in biological aeration, demand that a digester be provided. If F/M is less and tilling does not help, scrap out and restack
3	Drying beds are full of water from rains	Nothing that can be done about this. If rainfall is frequent, demand mechanized dewatering facility	Nothing that can be done about this. If rainfall is frequent, demand mechanized dewatering facility	

APPENDIX B.6.1 TYPICAL LEDGER AND RECORDS

Table B6.1-1 Operational record: Power Receiving and Transforming Equipment

Time	Transaction		Receiving						Wastewater pump transformer					No.2 blower			Lighting transformer					Main building power trans				
			Contact: 463kW						3φ415V 150kVA					6600V 80kW			1φ210V 150kVA					3φ210V 300kVA				
	Center		M102	M103	M102	M103	Center		Center		L101			Center			Center		L102			Center		L105		
	Energy Consumed		Voltage	Current	Power	Wattage	Wattage-h		Wattage-h		Voltage	Current	Temperature	Wattage-h		Current	Wattage-h		Voltage	Current	Temperature	Wattage-h		Voltage	Current	Temperature
	kWh		V	A	%	kW	kWh		kWh		V	A	°C	kWh		A	kWh		V	A	°C	kWh		V	A	°C
	Reading	Difference	6600	60			Reading	Difference	Reading	Difference	210	714	140	Reading	Difference	10.1	Reading	Difference	210	714	140	Reading	Difference	210	714	140
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24																										
Today's Reading																										
Yesterday's Reading																										
Difference																										
Multiplying ratio		×720						×10					×10			×10					×10					×10
Wattage																										

Transaction wattage-h	kWh
Max. wattage per hour	Time kWh
Max. kWh/Contact kWh	%

Non-utility generation	Wattage	Time
Today's reading		
Yesterday's reading		
Difference		
Multiplying ratio	×10	
Generated wattage-h		

Power	No.2 main building equipment	No.2 main building equipment	Grit chamber equipment	Reservoir water	Blower for adjustment
Today's reading					
Yesterday's reading					
Difference					
Multiplying ratio	×10	×10	×10	×10	×10
Generated wattage-h					

Instructions:

1. Voltage is obtained by measuring RS phase (RT phase in case of single phase). Current is obtained by measuring R phase.
2. Indicate the max. wattage per hour by transaction wattage.

Note: These Appendices are only Indicative and the STP Operator has to develop their own reports and ledger sheets , based on the equipments installed

Table B6.1-2 Monthly Report: Electric Power Receiving

	For transaction			Receiving	Sewage pump	No.2 blower	Main building power	Main building lighting	Sewage treatment power	Main building facility power	Grit chamber facility power	Reservoir water	Blower for adjustment	Pump well draining	Power by non-utility power generation	Hours of generation
	Contract: 463kW				150kVA	80kW	300kVA	150kVA	200kVA	178kW	91kW	91kW	30kW	11kW	500kW	
	kWh	Msx./h	%	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	h
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30																
31																
Total																
Max.																
Min.																
Ave.																
Ratio																

Summary		
Transaction		kWh
Contents	Pump	kWh
		%
	Blower	kWh
		%
	Power	kWh
		%
	Lighting	kWh
		%
	Others	kWh
		%
Max./h		kWh
Max./Contract		%
Electricity Charge		INR
Effluent volume		m^3
Charge/ flow rate		INR/m^3
Non-utility power generation		
Power		kWh
Running hours		h
Contents	Failure	h times
	Inspection	h times
Oil consumption		L
Fuel		ms/kWh

Table B6.1-3 Ledger for Electrical Equipment

	Classification		File No.		

Name		Location		Related Ledgers	( )	( )
		Fixed asset No.			( )	( )

Items on name plate	Capacity			Rotor	Voltage	V	Others	Insulator type							
	Number of poles				Current	A		Insulation resistance allowance							
	Phase				Type			Rotating direction							
	Frequency	Hz		Rotation rate		rpm		Lead wire direction							
	Voltage	Primary	V	Secondary	V			Impedance voltage							
	Current		A		A	Specification		Test performance chart	Frequency						
	Model			Manufacturer					Voltage						
	Specification			Lot No.					Current						
				Date of mfg.					Loss						
Coil	Model	( )	( )	Reducer	Reduction ratio				Measuring position	1) mm	2) mm				
	Sleeve Diameter	( )	( )		Mode 1					3) mm	4) mm				
	Sleeve Length						Related charts	Name	Chart No.			Name		Chart No.	
	Wire Type				Manufacturer										
	Wire Thickness			Starting resistor	Voltage	V									
	No. of coils				Current	A	Special notes								
	Total weight				Resistance	Ω									
					Mode 1										
					Manufacturer										

Source: JICA, 2011

Table B6.1-4 Electrical facility ledger (Distributing board)

		Classification No.		File No.	

Name		Problem		Related Ledgers	( )	( )
		Fixed asset No.			( )	( )

Indicating Instrument	Specification	Grade	Mode1	Quantity	Protective instrument, relay	Adjustment range	Adjustment time	Mode 1	Lot No.	Manufacturer	Date of mfg.

( ) Breaker				Disconnector		Transformer		
Mode 1		Specification	kV A	Mode 1		PT CT		
Weight	kg	Oil quantity	L	Specification	kV A	Transforming ratio		
Breaking capacity	kVA at			High-voltage soluble material		Specification load		
Operation power	Input V A			Mode 1		Mode		
	Out put V A			Specification	A	Lot No.		
Lot No.		Date of mfg.		Receiving wire		Manufacturer		
Manufacturer				Type		Quantity		
Other				Thickness	mm	Others		

Use	Knife-edge switch, NFB			Soluble material		Electromagnetic switch			Electromagnetic Connector		Thermo electric Connecto r	Supply wire (sq.m.) (mm^2)	Load kW	Indicator lamp	White PC
	Specification A	Voltage	Pole	Holder	Element	Model		Qty.	Model	Qty.					Red PC
															Green PC
														Size of distributing board	
														Height	mm
														Width	mm
														Depth	mm
														Operation switch	
														Distributing board	
														Date of mfg.	
														Manufacturer	
														Lot No.	
														Chart No.	
														Related ledger	
Other items															

APPENDIX 6.2 PREVENTIVE MAINTENANCE

6.2.1 MOTOR

a. Daily

- Check air draft through motor
- Check bearing temperatures
- Check for any undue noise or vibration

b. Monthly

- Observe presence of oil, grease in bearings from the type of noise when it is in operation. If necessary top up
- Nothing special other than the daily checks

c.Quarterly

- Blow away dust and clean any splashes of oil or grease
- Check wear of slip ring and brushes; smoothen contact faces or replace, if necessary. Check spring-tension. Check brush setting for proper contact on the slip-ring.
- Check cable connections, terminals and insulation of the cable near the lugs: clean all contacts; if insulation is damaged by overheating investigate and rectify. All contacts should be fully tight.

d. Semi-annual

- Check condition of oil or grease; and replace if necessary. While greasing avoid excessive greasing.
- Test insulation by megger.

e. Annual

- Check Coupling and pins for excessive/unequal wear/damage. Replace if necessary and realign
- Examine bearings for flaws, clean and replace if necessary.
- Check end-play of bearings and reset by lock-nuts, wherever provided.

f. Bi-annual

- Same as annual

6.2.2 PANEL, CIRCUIT BREAKER, STARTER

a. Daily

- Check the phase-indicating lamps.

- Note readings of voltage, current, frequency, and others.
- Note energy-meter readings.

b. Monthly

- Examine contacts of relay and circuit-breaker. Clean, if necessary.
- Check setting of over-current relay, no-volt coil and tripping mechanism, and oil in the dash-pot relay.

c. Quarterly

- Check fixed and moving contacts of the circuit- breakers/switches. Check and smoothen contacts with fine glass-paper or file.
- Check condition and quantity of oil/liquid in circuit-breaker, auto-transformer starter and rotor-controller.

d. Semi-annual

- Nothing special.

e. Annual

- All indicating meters should be calibrated.

f. Bi-annual

- Same as annual.

6.2.3 TRANSFORMER SUBSTATION

a. Daily

- Note voltage and current readings.

b. Monthly

- Check the level of the transformer oil.
- Confirm that the operation of the GOD (ground operated disconnection) is okay.
- Check temperatures of the oil and windings.
- Clean radiators to be free of dust or scales.
- Pour 3 to 4 buckets of water in each earth-pit.

c. Quarterly

- Check condition of the H.T. bushing.
- Check the condition of the dehydrating breather and replace the silica-gel charge, if necessary. Reactivate old charge for reuse.

d. Semi-annual

- Check di-electric strength and acid test of transformer oil and filter, if necessary.
- Test insulation by megger.
- Check continuity for proper earth connections.

e. Annual

- Check resistance of earth pit/earth electrode.

f. Bi-annual

- Complete examination including internal connections, core and windings.

Source: CPHEEO, 1993

Note: These Appendices are only Indicative and the STP operator has to develop their own reports and ledger sheets , based on the equipment's installed

APPENDIX B.6.3 TROUBLESHOOTING FOR ELECTRICAL FACILITIES

Table B6.3-1 Electric motors

Trouble	Cause	Remedy
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 very 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 replace shaft or bearing 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 filled more than the two-third level
	Broken ball or rough races	Clean housing thoroughly and replace bearing
Motor dirty	Ventilation passage blocked. Windings coated with fine dust or lint (dust may be cement, sawdust, rock dust, grain dust and the like)	Dismantle entire motor and clean all windings and parts 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
Motor stalls	Motor over loaded	Check for excessive rubbing or clogging in pump
	Low voltage	Correct voltage to rated value
	Correct voltage to rated value	Fuses blown, check overload relay, starter and push button
	Mechanical locking in bearings or at air gap	Dismantle and check bearings. Check whether any foreign matter has entered air gap and clean
Motor does not start	No supply voltage or single phasing or open circuit or voltage too low	Check voltage in each phase

Trouble	Cause	Remedy
	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 poor contact or open circuit. Make sure that brushes of slip ring motor are making good contact with the rings
	Rotor defective	Check for broken rings
Motor runs and then stop	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
		Consult manufacturer on suitability for design duty and load
Motor does not accelerate to rated speed	Voltage too low at motor terminals because of line drop	Check voltage, change tapping on transformer
	Broken rotor bars	Look for cracks near the rings
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 increase)
	Timer setting of starter is incorrect	Reduce load. (Note that if motor is driving a heavy load or is starting up a long line of shafting, acceleration time will increase)
	Applied voltage too low	Correct the voltage by changing tap on transformer. If voltage is still low, take up the matter to power supply authority
Motor overheats while running	Check for overload	If overloaded, check and rectify cause of over load. Overloading may be due to system fault, for example, if pipeline bursts, the pump may be operating at low head causing overload of motor. Vortices in sump also may cause overload
	End shields may be clogged with dust, preventing proper ventilation of motor	Blow off dust from the end shields
	Motor may have one phase open	Check to make sure that all leads are well connected
	Unbalanced terminal voltage	Check for faulty leads or faulty connections from transformers
	Weak insulation	Check insulation resistance, examine and re-varnish or change insulation
	High or low voltage	Replace worn bearings
		Check for true running of shaft and rotor

Trouble	Cause	Remedy
Motor vibrates after connections have been made	Motor misaligned	Realign
	Weak foundations or holding down bolts loose	Strengthen base plate/ foundation; tighten holding down bolts
	Coupling out of balance	Balance coupling
	Defective ball or roller bearings	Replace bearing
	Bearings not in line	Line up properly
	Single phasing	Check for open circuit in all phases
	Excessive end play	Adjust bearing or add washer
	Resonance from supporting structure or foundation or vibration of adjoining equipment	Consult expert
Scraping noise	Fan rubbing air shield or striking insulation	Check for cause and rectify
	Loose on bed plate	Tighten holding down bolts
Motor sparking at slip rings	Motor may be over loaded	Reduce the load
	Brushes may not be of appropriate quality and may not be sticking in the holders	Use brushes of the recommended grade and fit properly in the brush holder
	Slip ring dirty or rough	Clean the slip rings and maintain its smooth glossy appearance; ensure they are free from oil and dirt
	Slip rings may be ridged or out of turness	Turn and grind the slip rings in a lathe to a smooth finish
Leakage of oil or grease on winding	Thrust bearing oil seal damaged	Clean the spilled oil on winding. Replace oil seal
	Excessive oil, grease in bearing	Reduce quantity to correct extent. Grease should be filled up to maximum half space in bearing housing

Table B6.3-2 Capacitors

Trouble	Cause	Remedy
Leakage of heclor*	Leaking welds & solders	Repair by soldering
	Broken insulators	Replace insulators
Overheating of unit	Poor ventilation	Arrange for circulation of air either by reinstalling in a cool and ventilated place or arrange for proper ventilation
	Over voltage	Reduce voltage if possible, otherwise switch off capacitors
Abnormal bulging	Gas formation due to internal arcing	Replace the capacitor
Cracking sound	Partial internal faults	Replace the capacitor
HRC Fuse blowing	Short external to the units	Check and remove the short
	Over-current due to over voltage and harmonics	Reduce voltage and eliminate harmonics
	Short circuited unit	Replace the capacitor
	kVAR rating high	Replace with bank of appropriate kVAR
Capacitor not discharging	Discharge resistance low	Correct or replace the discharge resistance
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.

Table B6.3-3 Starters, breakers, and control circuits

Trouble	Cause	Remedy
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 not reset	Clean and reset relay
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
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
	Sustained overload	Check overcurrent setting
		Check for short circuit or earth fault
		Examine cause of overload and rectify

Trouble	Cause	Remedy
	Loosen connection	Clean and tighten
Starter / breaker not tripping after overcurrent or short circuit fault occurs	Inadequate lubrication to mechanism	Lubricate hinge pins and mechanisms
	Mechanism out of adjustment	Adjust all mechanical devices such as 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 overcurrent relay and heater
	Heater assembled incorrectly	Review installation instructions and correctly install the heater assembly
	Relay not operating due to: -Blown fuse -Loose or broken wire -Relay contacts damaged or dirty -Damaged trip coil -C.T. damaged	-Replace fuse -Repair faulty wiring; and ensure that all screws are tight -Replace damaged contacts -Replace coil -Check and repair / replace
Overheating	Contacts burnt or pitted.	Clean the contacts with smooth polishing paper or if badly burnt / pitted, replace contacts. (Contacts should be cleaned with smooth polishing paper to preserve faces. File should not be used)
	Loose power connection	Tighten the connection
	Sustained overcurrent or short circuit / earth fault	Check cause and rectify
	Poor ventilation at location of starter / breaker	Improve ventilation
Overheating of auto transformer unit	Winding design improper	Rewind
	Transformer oil condition poor	Replace transformer oil in auto-transformer unit
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; test with test lamp
	Poor contact in control circuit	Replace coil. Rating should compatible for system nominal voltage
Contacts welding	Abnormal inrush of current	Check for grounds and shorts in system as well as other components such as circuit breaker

Trouble	Cause	Remedy
	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
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 high current	Check for short circuit, earth 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 of foreign matter on contact surface	Clean with carbon tetrachloride
	Short circuit	Rectify fault and check fuse or breaker rating whether correct
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
Magnets & other mechanical parts worn out/broken	Too much cycling	Replace part and correct the cause of damage
Noisy magnet (humming)	Magnet faces not mating correctly	Replace magnet assembly. Hum may be reduced by removing magnet armature and rotating through 180°
	Dirt oil or foreign matter on magnet faces	Clean magnet faces with carbon tetrachloride
	Low voltage	Check system voltage and voltage dips during start
Failure to pick-up and / or seal	Low voltage	Check system voltage and voltage dips during start
	Wrong coil	Check coil voltage rating which must include nominal voltage and frequency of system
	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
Failure to drop out	Gummy substances on pole faces or in mechanism	Clean with carbon tetrachloride
	Worn or rusted parts causing binding, for instance coil guides, linkages	Replace contactor
	Improper mounting of starter	Review installation instructions and mount properly

Trouble	Cause	Remedy
Failure to reset	Broken mechanism worn parts, corrosion, dirt, etc.	Replace overcurrent relay and heater
Open or welded control circuit contacts in over current relay	Short circuit in control circuit with too large rating of protecting fuse	Rectify short circuit in general. Fuses over 10A rating should not be used
Insufficient oil in breaker/ starter (if oil cooled)	Leakage of oil	Locate point of leakage and rectify
Oil dirty	Carbonisation of moisture from atmosphere	Clean inside of tank and all internal parts. Fill fresh oil
Moisture present in oil	Condensation of moisture from atmo-sphere	Same as above

Table B6.3-4 Panels

Trouble	Cause	Remedy
Failure to reset	Bus bar capacity inadequate	Check and provide additional bars in combination with existing bus-bars or replace bus-bars
	Loose connection	Improper ventilation
	Improper ventilation	Improper ventilation
Insulator cracked	---------	Replace the insulator

Table B6.3-5 Cables

Trouble	Cause	Remedy
Over heating	Cable size inadequate	Provide a cable in parallel to existing cable or higher size cable
		Increase clearance between cables
Insulation burning at Termination	Improper termination in lug termination	Check size of lug. If not properly crimpled, correct it
		Check whether all stands of cable are inserted in lug. Use a new or higher size lug if necessary

Table B6.3-6 Transformers

Trouble	Trouble shooting procedure	Cause	Remedy
Abnormal noise	Listen to the noise at various points of the transformer and find out the exact location by means of a solid piece of wood or insulating material placed on body of transformer tank at various points. This helps in determining whether the noise is from the inside of the transformer or is only an external one	A. External Noise: A loose fixing bolt/nut of the transformer B. Noise originating from the inside of the transformer: In the case of old transformer, possibly due to the windings having become slightly slack	A.Tighten the fixing bolts and nuts and other loose metallic parts B.In the case of small transformer and if such facilities are available, open the transformer and remove any slackness by placing shim made of insulated board. In case of large transformers, contact the manufacturer or transformer repairer
High Temperature	The temperature rise of transformer during 10-24 hours of operation is observed. The input current, oil temperature are noted down at intervals of half an hour and tabulated	a) Transformer is over loaded b) Transformer room is not properly ventilated c) Certain turns in the winding are short circuited	a) Reduce the load to the rated load b) Improve the ventilation of the transformer room to achieve effective air cooling c) Major repairs are necessary and should be taken up in consultation with an experienced Electrical Engineer and transformer repairer
	The transformer becomes hot in a relatively short period; transformer oil escapes from the conservator or there is even appearance of gas	The transformer has a major defect	Take action for major repairs in consultation with an experienced Electrical Engineer and transformer repairer
	Abnormal heating of one terminal	Poor termination either inside or outside the transformer	a)External contacts should be checked and put in order especially those in the aluminium bus bars b) If heating persists, action for major repairs should be taken in consultation with an experienced Electrical Engineer
Tripping of circuit breaker or blowing of fuses	----------	a) Short circuit in the windings b) Damage in the insulation of the winding or in one terminal	Action for major repairs should be taken in consultation with an experienced Electrical Engineer and transformer repairer

Trouble	Trouble shooting procedure	Cause	Remedy
Frequent change of silica gel colour	----------	a) Breather leakage b) Breather oil level low c) Absorption of moisture	a) Replace packing b) Check oil seal. Top up oil c) Remove moisture completely
Oil leak at joints / bushing / drain valve	----------	a) Defective packing b) Loose tightening c) Uneven surface d) Bushing cracked e) Drain, valve not fully tight	a) Replace packing b) Tighten properly c) Check and correct it d) Replace bushing along with washer e) Tighten valve and plug
Low insulation resistance	----------	a) Moisture absorption by winding b) Contaminated oil c) Presence of sludge	a) Heat the windings, by operating transformer on no-load, and check whether insulation resistance improves. If no-improvement is observed after operation for 5-6 hours, filter the oil b) Replace with proper oil c) Filter or replace the oil
High Temperature	The transformer becomes hot in a relatively short period; transformer oil escapes from the conservator or there is even appearance of gas	The transformer has a major defect	Take action for major repairs in consultation with an experienced Electrical Engineer and transformer repairer
	Abnormal heating of one terminal	Poor termination either inside or outside the transformer	a)External contacts should be checked and put in order especially those in the aluminium bus bars b) If heating persists, action for major repairs should be taken in consultation with an experienced Electrical Engineer
Water inside tank	----------	a)Defects in joints b) Moisture condensation c) Oil mixed with water when topping up	a) Rectify the defect b) Drain water and dry the moisture in winding c) Heat the winding on no-load. Recheck dielectric strength and filter if necessary

Trouble	Trouble shooting procedure	Cause	Remedy
Overheating of cable ends and cable terminals	----------	Loose connections	Check and tighten the connections
Neutral ground conductor (earth strip) burnt	----------	a) Loose connections b) Large fault current	Replace the grounding conductor

Source: CPHEEO, 2005

APPENDIX B.7.1 MINIMUM LABORATORY EQUIPMENTS NEEDED FOR TESTS

Table B7.1-1 Minimum laboratory equipments needed for tests

Equipment	Type of Plant	
	(A) For consent parameter (BOD, SS, pH)	(B) For plant operating parameter
Analytical Balance	x	x
Autoclave		x
Centrifuge		x
Chlorine comparator		x
Colony counters		x
Demineraliser		x
Dissolved Oxygen sampler		x
Drying oven (hot air)		x
Fume cupboards		x
Gas liquid chromatograph		x
Hot plates	x	x
Incubator 20°C/27°C (BOD)	x	x
Incubator 30°C (Bacteriological)		x
Kjeldahl Digester Unit		x
Magnetic stirrers		x
Microscope, binocular with oil immersion and movable stage counting cell		x
Membrane Filter Assembly		x
Muffle Furnace		x
Orsat or equivalent gas analysis apparatus		x
pH comparator (Colorimetric)	x	x
pH meter with reference & spare electrodes		x
pH meter portable	x	x
Refrigerator		x
Sedgwick Rafter funnel		x
Sludge sampler		x
Soxhlet extraction unit		x
Spectrophotometer (atomic absorption)		x
Spectrophotometer with or without U-V rage or photo electric colorimeter		x

Equipment	Type of Plant	
	(A) For consent parameter (BOD, SS, pH)	(B) For plant operating parameter
Total organic carbon analyser		x
Turbidimeter		x
Vacuum pump		x
Water bath (thermostat controlled)		x
Dessicator	x	

*NB: (1) For plant operating parameters, equipment as needed will also be provided in the laboratory of STP.
(2) Equipment in column B may be in plant laboratory itself or in a regional laboratory to serve multiple STPs.

APPENDIX B.7.2 SUGGESTED LABORATORY SERVICE INFRASTRUCTURE FOR MONITORING WATER QUALITY

Table B7.2-1 Suggested laboratory service infrastructure for monitoring water quality

S.No.	Level	Minimum Recommended Staff	Remarks
1	Basic Laboratory a. Primary Health Centre / Village Level	1. Lab. Assistant /Technician 2. Lab. Attendant	For routine bacteriological and physicochemical tests, the samples should be sent to municipal / district level laboratory periodically
	b. Municipal / District Level (Plant capacity > 50MLd)	1. Chief Analyst 2. Chemist 3. Bacteriologist 4. Assistant Chemist 5. Lab. Assistant / Technician 6. Lab. Attendants 7. Driver 8. Helper	Whenever STP laboratory is existing
2	State / Regional Level Laboratory	1. Chief Analyst (Higher Scale) 2. Chemist 3. Bacteriologist 4. Biologist 5. Assistant Bacteriologist 6. Assistant Biologist 7. Lab. Assistant / Technician 8. Lab. Attendants 9. Driver 10. Helper	

Note: 1. Kindly refer to Manual on Water Supply and Treatment, III Edition, May 1999.
2. The level and the no. of the personnel shall be decided by the respective agencies depending on magnitude of the site.

APPENDIX B.9.1 HEALTH AND SAFETY POLICY

The agencies involved in the project development such as the owner, consultant and contractor jointly or separately shall have a written statement prescribing the health and safety policy of the organisation.

The health and safety policy conveys the management commitment and intent of the organisation towards health and safety, its organisation and arrangements to ensure that the set objectives are met. It also provides a framework for establishing, maintaining and periodically reviewing health and safety objectives and targets.

Health and safety policy shall meet the requirements of Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and IS 18001.

The policy shall be communicated to all stakeholders through display and other means. The policy shall be displayed in local language(s) which may be understood by majority of the workmen.

Guidelines on O&M of sewerage and sewage treatment for operators to help them in practicing their works in accordance with health and safety requirements specified for sewerage works are presented below:

9.1.1 APPLICABLE FACTORS

The applicable factors under this important section will be the procedures to be followed by the operator while working in confined spaces, type of shoes to be worn, personal hygiene and climbing ladders plus a formal appreciation of first aid.

9.1.2 WORKING IN CONFINED SPACES

This category is the worst location for possible fatal accidents in the STP. A confined space is defined as (1) Cramped entry and exit, (2) Absence of broad daylight and ventilation and (3) Places meant for very limited persons like one or two only to get in. The dangers are caused by

- Oxygen less situation
- Flammable situation
- Toxic gas presence
- Engulfment hazards
- Shouts not being heard outside
- Wet and / or slippery surfaces
- Loosely fitted objects that may fall down

The precautions to be taken before entry into these spaces when required are

- Certifying by the plant superintendent in writing that it is free of H_2S, CO and Methane

- Availability of a portable air compressor which draws free unpolluted air and pumps in
- Personal Respirator with adequate Oxygen cylinder and the Miner's lamp
- Availability of a strong rope tied to the person and rescue team in position
- The person to have undergone training in safety with St. John Ambulance
- The person to have comfortable and tight fitting garments
- The person to wear only anti-skid shoes.
- The person to have special goggles securely worn over the eyes
- The person to complete his urination and toiletries before entry
- The person to have been in continues duty for at least a week as on that date
- The person not to have returned from medical leave within 7 days of the date of entry
- The person not to a be a known asthmatic or cardiac patient
- The person not to be aged more than 35 years
- Above all, a person who is not mentally scared to get in.

9.1.3 TYPES OF SHOES TO BE WORN

Very often, it is believed that any shoe in the market is good for working in a STP. This is not correct. There are special anti-skid shoes with metal cladding over the toe portion. These are to be provided by the employer and the operator should not use it outside the STP.

9.1.4 PERSONAL HYGIENE

The following procedures should be followed by the operator scrupulously in and out of the STP.

- Keep the fingers of the hand away from ears, nose, eyes, mouth and unnecessary scratching
- While handling any equipment, wear gloves or poly bags slipped over the palm and wrists
- When there is an injury to the hand, do not handle any equipment or collect sample
- Before and after food and work wash hands with anti septic solution, soap and fresh tap water
- After the work, take a bath before leaving the STP
- Ensure fingernails are cut properly and there are no deposits
- Insist on two separate lockers one for formal cloths and one for STP cloths
- Ensure you are vaccinated by the employer against Hepatitis, Typhoid, Rubella [for women], Tetanus, Diphtheria, Pox and Measles.
- Insist on mediclaim to be taken for you by your employer
- Insist on personal accident policy to be taken for you by your employer

9.1.5 CLIMBING LADDERS

This is one location of accidents for want of certain simple precautions as follows.

- Make sure the ladder is anchored to the floor securely and not simply resting
- Ensure that the ladder is provided with non conducting shoes and not resting on wet surfaces
- Feel the firmness of each step before you put your whole weight on it
- Tie the top of the ladder to a firm anchor once you climb there
- Ensure that at least 3 steps are rising above the level where you are required to work
- If it is simply resting, call an assistant to stand up and buttress it without slipping
- Verify whether the horizontal clearance is minimum one fifth for one meter length of ladder
- Avoid doing any work by standing on the top 2 or 3 steps of the ladder
- Do not use Bamboo Ladders. They may be weak and suddenly collapse
- Never catch the sides of a ladder. Catch the upper steps
- Do not catch any part of a steel ladder without at least a poly slip on cover over the palm
- Make sure nobody walks below the ladder while you are using it
- Finally, do not climb unless you need to !

9.1.6 ELECTRICAL RELATED SAFETY

- Unless you are qualified for the job, do not undertake it even to replace a fuse or bulb
- Ensure that you have the appropriate gloves, shoes and garments that fit reasonably tight
- Always use local circuit cut-outs before attending to repairs
- Avoid metallic ladders and metallic tape measures near electrical systems
- The best ladder is one made out of teakwood and preserved with anti-termite treatment
- Never work alone and keep an assistant with you all through the work
- Always, de-energize and ground a circuit before venturing any repairs
- Always use approved instruments like tong testers etc and not naked wire and bulb
- Free hanging neck chains are to be removed and kept in pockets while on the job
- All tools shall be insulted in their handles
- Do not latch on to other metallic fittings like piping, etc., while on the job
- If require to use flashlights, use those made of external non-metallic parts
- If wires are found to be dangling, do not attempt to clamp them. Instead, try to reroute them

9.1.7 FIRST AID KIT, SUPPORT FACILITIES & DISPENSATION

The first aid kit should minimally include the following

- A leaflet explaining how to use the kit

- Sterilized dressings of assorted sizes
- Plaster casts for waterproof casts
- Bandages of assorted sizes
- Adhesive plasters of assorted sizes and a blunt edges stainless steel long scissors
- Sterilized water of at least 2 liters
- Eye protection pads
- Safety pins of assorted sizes
- Disinfectant lotions
- Unused sealed twin blade razor
- Eyebaths with double showers focussing on the eyes
- An easily identifiable and reachable shower bath with non-slip grip type flooring
- Wall hung charts showing artificial resuscitation in both English and local language
- Wall hung posters showing the telephone numbers, locations and names of medical centers
- Wall hung posters of ambulance centers, rickshaw stands and truck terminals
- Brief history of previous accidents and lessons learned therefrom
- A well ventilated rest room with a cot and mattress of standard height
- A facility for accessing safe drinking water and an instant heater geyser

If the person is having breathing difficulty, check clothing around the chest and neck and loosen them and then turn him flat on back and chin up and apply artificial resuscitation and later shift his position sideways to the recovery position. If the person is having a cut wound, apply pressure on the upper portion of the limbs and tie up the limb reasonable tight to prevent blood loss. If the person has fainted, just check for breathing and whether he needs artificial resuscitation and administer. In all cases, rush to a nearest medical center. If the person is frothing in the mouth, do not interfere and rush to the nearest medical center.

9.1.8 OPERATOR'S RESPONSIBILITIES

The responsibilities of the operator are most important and are as follows.

- Familiarize with the wall charts, wall posters and telephone procedures to medical centers
- Do not go into a work unless you have observed the environment and understood it.
- All water other than from tap water is to be considered as unsuitable for human contact
- Do not operate any equipment unless you are trained in it.
- If you feel something unusual in a moving machinery, do not panic and call your superintendent
- Do not hide other's unsafe practices from your employer. Please report discretely

- Never hurry up in physical motion when on duty. Be safe and steady in your movements
- Never chit chat in working areas or while standing on structures of the STP
- Never climb up or climb down cat ladders by facing the airside of the ladder. Face the wall
- Always use reasonably and comfortably fitting dresses. Remove neck chains while on duty
- Ensure that you set an example to be followed and not reported upon.

9.1.9 LEPTOSPIROSIS

This is strange disease caused by rats which fall into water source and spread the respective viruses. The disease is normally noticeable only under advanced conditions and usually the treatment and recovery is prolonged. Rats are a menace in sludge drying beds in hot climates as they seek asylum from the heat and find food easier. The drinking water sump should be checked by you every day in your shift to ensure that there is no ratfall into the sump. If you detect it, immediately shut off all water connections to the STP and immediately alert your plant superintendent and the chief executive officer. Also inform the health officer of the local authority.

9.1.10 THE WATCHWORD

The watchword should be your own safety in the first place, so that alertness becomes automatic.

9.1.11 TESTS FOR CHLORINE

Chlorine is not recommended to be used with sewage under any circumstances on a continued scale. However, under special circumstances, chlorine may be applied for a brief period like in flood seasons when large quantities of sewage may be bypassed. During these times, some knowledge of chlorination safety is necessary. The important points are as follows.

- Chlorine gas has specific gravity of 2.49 (Air =1)
- Normally chlorine is got in steel cylinders in gas form and depressurized for use
- The gas may leak sometimes from the joints or the cylinders
- The gas has a pungent smell
- Dip a cotton swab in ammonia solution and move it near the cylinder and joints
- If white fumes are observed, it shows chlorine is leaking there
- The gas will be settling down at the ground level and sink into pits
- As the gas spreads on the ground, the grass will be scorched leaving a tell-tale
- Never bend low while testing for chlorine with a swab
- Stand erect and use an extension twig or stick
- Closing the valve of the cylinder may stop leaks at the joint in the cylinder
- Closing the valve will also help in checking whether the cylinder is leaking
- If the cylinder is leaking, try to douse the cylinder continuously with gentle water shower

- This will dissolve the chlorine and help in containing the quick spread of the gas
- Call the supplier or the fire department immediately
- Ensure nobody is working at ground level or in pits near the cylinder
- Do not try to wrap any cloth etc. over the leaking cylinder. Closeness is to be avoided.
- The chlorine smell will anyway make it impossible to be near the cylinder
- If available, locate a nearby pit into which the container can be gently rolled.
- Carry out the rolling using long handled sturdy rods or bamboo ladders
- Once rolled into the pit, do not bend down into it. You are only containing the gas there
- In case someone swoons due to chlorine gas, rapidly remove him to the first floor
- If first floor is not available, use at least an office table to elevate him
- Allow fresh air and avoid crowding around him
- Keep him facing up and the head well back and tongue not in the way
- Apply artificial respiration mouth to mouth
- Voluntarily carry out a monthly drill in artificial respiration
- Always keep a cool head and never get perturbed
- Never try to find out how this leak occurred before you have stooped the leak
- Use common sense

APPENDIX B.9.2 CHARACTERISTICS OF COMMON GASES CAUSING HAZARDS

Table B9.2-1 Characteristics of common gases causing hazards

Sl No	Name of Gas	Chemical formula	Common properties	Specific gravity or vapour density	Physiological effects	Maximum safe limit %	Exposure		Explosive limit %		Likely location of highest concentration	Most common sources
							%	ppm				
						60-minutes	8 hours		lower	upper		
1	Carbon dioxide	CO_2	Colourless, odourless when breathed in large quantities may cause odd taste, non poisonous	1.53	Cannot be endured at 10 for more than few minutes even if subject is at rest and oxygen content is normal acts on respiratory nerves	4.0 to 6.0	0.5	5000	---	----	At bottom when heated may stratify at points above bottom	Products of combustion sewer gas sludge gas also issued from carbonaceous states
2	Carbon monoxide	CO	Colour less odourless, tasteless inflammable poisonous non irritating	0.97	Combines with haemoglobin of blood headache in few hours at 0.02%, unconsciousness in 30 mins at 0.2 % to 0.25 %, and total unconsciousness in few minutes at 0.1%	0.04	0.005	50	---	----	Neat top especially if present with illuminating gas	Manufactured fuel gas, fuel gas products combustion products of motor exhausts fuel almost any kind
3	Chlorine	Cl_2	Yellowish green colour detectable in very low concentration, non-inflammable	2.49	Irritates respiratory tracts. Kills most animals in very short time at 0.1 %	0.0004	0.0001	1.0	---	----	At bottom	Chlorine cylinders and feed line leaks

Sl No	Name of Gas	Chemical formula	Common properties	Specific gravity or vapour density	Physiological effects	Maximum safe limit %	Exposure		Explosive limit %		Likely location of highest concentration	Most common sources
							%	ppm				
						60-minutes	8 hours		lower	upper		
4	Gasoline	C_2H_2 to C_8H_{25}	Colourless, odour noticeable at 0.03% inflammable	3.0 to 4.0	Anaesthetic effect when inhaled rapidly fatal at 2.4 % dangerous for short exposure at 1.12 to 2.2 %	0.4 to 0.7	0.1	1000	1.3	6.0	At bottom	Service stations, garages storage
5	Hydrogen	H_2	Colourless, odourless tasteless inflammable	0.07	Acts mechanically to deprive tissues of oxygen: does not support life	----	---	---	4.0	74.0	At top	Manufacture fuel gas sludge
6	Hydrogen sulphide	H_2S	Rotten egg odour in small concentra-tion, odour not evident at high concentration. Colourless, Inflammable	1.19	Exposure for 2 to 15 minutes at 0.01% impairs sense of smell exposure to 0.07 to 0.1% rapidly causes acute poisoning paralyses respiratory centre, death in few minutes at 0.2 %	0.02	0.001	10	4.30	46.0	Near bottom but may be above bottom. If air is heated and highly humid	Coal gas, petroleum, sewer gas, fumes from blasting sludge gas
7	Methane	CH_4	Colourless odourless tasteless highly inflammable non poisonous	0.55	Acts mechanically to deprive tissues of oxygen does not support life	Probably no limit provided oxygen percentage is sufficient	1.0	1000	1000	15.0	Normally at top extending to a certain depth	Natural gas, sludge gas manufactured fuel gas, sewer gas in swamps or marshes.
8	Nitrogen	N_2	Colourless tasteless non inflammable principal constituent of air (about 79%)	0.97	Physiologically inert	----	----	----	----	----	Near top but may be found at bottom	Sewer gas, sludge gas also issues from some rock strata

Sl No	Name of Gas	Chemical formula	Common properties	Specific gravity or vapour density	Physiological effects	Maximum safe limit %	Exposure		Explosive limit %		Likely location of highest concentration	Most common sources
							%	ppm				
						60-minutes	8 hours		lower	upper		
9	Oxygen	O_2	Colourless tasteless odourless supports combustion non poisonous	1.11	Normal air contains 21% of oxygen. Below 16% first signs of anoxia appears even in people who are resting. Below 14% anoxia such as faulty judgement even with minimal exertion. Below 10% dangerous to life. Below 6% is fatal.	--	--	--	---	----	Variables at different levels	Oxygen depletion from poor ventilation and absorption of chemical combustion of available oxygen
10	Sludge Gas	About 60% CH_4 and 40% CO with small amounts H_2, N_2, H_2S, O_2	May be practically odourless, colourless, inflammable	0.94	Will not support life	Would vary widely with composition	--	--	5.3	19.3	Near top of structure	For digestion of sludge in Tanks

Source: CPHEEO, 1993

APPENDIX B.9.3 CONFINED SPACE ENTRY PROCEDURE

The following steps are recommended prior to entry into any confined space:

- Ensure that all the employees involved in the confined space working have been effectively trained.
- Identify and close off or reroute any lines that may carry harmful substance(s) to, or through, the work area.
- Empty, flush, or purge the space of any harmful substance(s) to the extent possible.
- Monitor the atmosphere at the work site and within the space to determine if dangerous air contamination and/or oxygen deficiency exists.
- Record the atmospheric test results and keep these results at the site throughout the work period.
- If the space is interconnected with another apace, each space must be tested and the most hazardous conditions found must govern subsequent steps for entry into the space.
- If an atmospheric hazard is noted, use portable blowers to further ventilate the area; retest the atmosphere after a suitable period of time. Do not place the blowers inside the confined space.
- If the only hazard posed by the space is an actual or potential hazardous atmosphere and the preliminary ventilation has eliminated the atmospheric hazard or continuous forced ventilation alone can maintain the space safe for entry then only entry into the area may proceed.

The following must be observed before entry into a permit-required confined space:

1. Ensure that all personnel involved in confined space work have been effectively trained.
2. Identify and close off or reroute any lines that may carry harmful substances to, or through, the work area.
3. Wear appropriate, approved respiratory protective equipment.
4. Ensure that written operating and rescue procedures are at the entry site.
5. Wear an approved harness with an attached safety line. The free end of the safety line must be secured outside the entry point.
6. Test for atmospheric hazards as often as necessary to determine that acceptable entry conditions are being maintained.
7. Station at least one person to stand by on the outside of the confined space and at least one additional person within sight or call of the standby person.

8. Maintain effective communication between the standby person, equipped with appropriate respiratory protection, should only enter the confined space in case of emergency.

9. The standby person equipped with appropriate respiratory protection, should only enter the confined space in case of emergency.

10. If the entry is made through a top opening, use a hoisting device with a harness that suspends a person in an upright position. A mechanical device must be available to retrieve personnel from vertical spaces more than five feet (1.5meters) deep.

11. If the space already contains, or is likely to develop, flammable or explosive atmospheric conditions, do not use any tools or equipment (including electrical) that may provide a source of ignition.

12. Wear appropriate protective clothing when entering a confined space that contains corrosive substances or other substances harmful to the skin.

13. At least one person trained in first aid and cardiopulmonary resuscitation (CPR) should be immediately available during any confined space job.

Source: EPA, 2008

APPENDIX B.9.4 CONFINED SPACE PRE-ENTRY CHECKLIST

Table B9.4-1 Confined space pre-entry checklist

CONFINED SPACE PRE-ENTRY CHECK LIST /CONFINED SPACE ENTRY PERMIT

Date and Time issued: Date and time expires:

Job Site space ID.: Job Supervisor:

Equipment to be worked on: Work to be performed:

Standby personnel:

Atmospheric checks:

Time:

Oxygen: %, Toxic: ppm

Explosive: % Carbon Monoxide: ppm

Tester's signature:

	NA	Yes	No
1. Source isolation (No entry):			
Pumps or lines blinded, disconnected, or blocked	( )	( )	( )

	NA	Yes	No
2. Ventilation modification:			
Mechanical	( )	( )	( )
Natural ventilation only	( )	( )	( )

3.Atmospheric check after isolation and ventilation:

Time:

Oxygen: % > 19.5% Toxic: ppm < 10 ppm H2S

Explosive: % LFL < 10% Carbon monoxide: ppm < 35 ppm CO

Tester's signature:

4. Communication procedures:

5. Rescue procedures

	Yes	No
6. Entry, standby, and backup persons		
Successfully completed required training	( )	( )
Is training current	( )	( )

	NA	Yes	No
7. Equipment:			
Direct reading gas monitor tested	( )	( )	( )
Safety harnesses and lifelines for entry and standby persons	( )	( )	( )
Hoisting equipment	( )	( )	( )

Powered communications ( ) ( ) ( )
SCBAs for entry and standby persons Protective clothing ( ) ( ) ( )
*SCBA: Self-contained breathing apparatus
All electric equipment listed for Class I, Division I, Group D
and non-sparking tools ( ) ( ) ( )

8.Periodic atmospheric tests:

Oxygen: % Time: ; : %, : ; : %,: ; : %,
Explosive: % Time: ; : %, ; : %,: ; : %,
Toxic: % Time: ; : %, : ; : %,: ; : %,
Carbon-monoxide: % Time: ; : %, : : %,: ; : %,

We have reviewed the work authorised by this permit and the information contained herein. Written instructions and safety procedures have been received and are understood. Entry cannot be approved if any brackets ( ) are marked in the “No” column. This permit is not valid unless all appropriate items are completed.

Permit prepared by (Supervisor): Approved by (Unit Supervisor):

Reviewed by (CS Operations Personnel):

This permit has to be kept at the job site. Return job site copy to safety office following job completion.

Source: EPA, 2008

APPENDIX B.9.5 FIRST AID

9.5.1 TREATING WOUNDS

a. Caring for a skin tear

- Expose and treat the part with the wound taking care to not move it unnecessarily. Firstly, start removing clothes with no skin tear below and later, carefully remove clothes with skin tear below.
- Considering that bacteria may have entered the wound, first wash and disinfect your hands and apply antiseptic solution over a width of 2 to 3 cm around the wound. Using disinfected tweezers, apply disinfected gauze, and cover with bandage to prevent infection.

Take the following precautions to prevent infection of the wound:

- Always use paper, towel, cloth or hands that have been disinfected.
- Disinfect the wound and remove debris in the wound using tweezers. Leave debris that cannot be removed as-is; do not touch it with your finger.
- Do not wipe or wash the wound. If there is slight bleeding, do not try to stop the bleeding unnecessarily, since bacteria may be removed during initial bleeding.
- Remove the dirt in the wound using aqueous hydrogen peroxide. If the wound has oil or grease, wipe it off from around the wound to the outside using volatile oil or benzene, etc., and disinfect the wound using ethanol.
- Wound to the head, chest or stomach is generally a serious matter even if it looks minor from the outside. Notify the doctor as soon as possible after the patient has rested.

b. Care when there is no skin tear

- Limbs
  If the wound is minor, apply antiseptic solution. If swollen, apply cold compress; if there is suspicion of fracture or dislocation, tie a splint and apply a bandage.
- Head
  Even if the injury is minor, treat with care. If the person has headache or nausea, cool the head. If unconscious, or if there is bleeding from the ear, eye or nose, or if the patient is agitated, internal wound in the cranium may be a possibility; in such a case, let the patient lie down with the head kept high and immediately notify the doctor.
- Chest
  If the chest pain is unbearable and patient coughs suddenly, or if the patient’s breathing is laborious, or if blood is mixed with the sputum, allow the patient rest, and then immediately summon the doctor.

- Abdomen
  In case of severe pain or swelling in the abdomen, or nausea, there is a possibility of an internal injury. In such a case, ask the patient to fold his knees and lie down so that the skin on the abdomen sags. Never give any drink to the patient. Summon the doctor quickly.

c. How to stop bleeding

- Stopping bleeding by applying pressure directly
  Place clean gauze or handkerchief on the wound and apply pressure directly with your hand.

  If the bleeding is from a large blood vessel, and if bleeding does not stop even after you apply pressure using one hand, apply pressure with both hands leaning so that your body weight also exerts pressure.

  Take care not to touch the blood to prevent contamination when you try to stop the bleeding.

- How to use a tourniquet
  If there is considerable bleeding from a large blood vessel such as an artery in the arm or the leg, wrap a piece of cloth loosely around the part closer to the heart than the wound, and insert a stick or similar hard item through the knot.

  Insert a backing cloth between the stick and the arm so that the skin is not injured.

  Gently rotate the stick until the cloth tightens over the artery and bleeding stops. When the bleeding stops, fix the stick so that it does not move.

  If the arrival of the first aid team is likely to be prolonged, loosen the tourniquet once in 30 minutes to 1 hour so that blood just starts oozing; after blood flows for 1 to 2 minutes, tighten the tourniquet.

d. Treating electricity-related injury

- When electric current enters from the left hand, it flows through the heart; therefore, the symptoms are more pronounced when current enters from the left hand.
- The injury is more serious at the part where the electric current leaves the body than where it enters the body.

The following treatment is recommended:

- Turn off the switch. Wear dry leather shoes or rubber shoes, and dry leather or rubber gloves. Use bamboo or wood to isolate the person from the electric wire, or use a piece of cloth or wool to grip the hand and the clothes to pull the person away from the electric wire.
- Do not touch the person with your bare hands or with a wet object or metal.
- Place the person face up at a well-ventilated location; if the person has suffocated, revive with artificial respiration. If the person is delirious or has cramps, try to cool his head.

9.5.2 GAS POISONING

- Occurs when inhaling simple asphyxiant gas (nitrogen, hydrogen, helium, methane, ethane) and chemical asphyxiant gas (carbon dioxide, cyanide compound)

- If considerable amount of gas has been inhaled, move the patient quickly to a location with fresh air; if necessary, give fresh oxygen through oxygen supply kit, and immediately summon a doctor.

9.5.3 CHLORINE

- If chlorine gas has been inhaled

  Immediately call for the doctor, follow the doctor's instructions and take the actions mentioned below.

  Gently move the patient from the gaseous location to a safe place, preferably to a room of about 20°C. Keep the patient's head and back high while laying him to rest and cover the body with a blanket.

  If the patient has difficulty in breathing, give oxygen using oxygen supply kit.

  If breathing has stopped, give artificial respiration by the prone, face-down method.

- If chlorine has come in contact with the skin

  Immediately wash the affected part with plenty of water. Quickly remove clothes wetted by liquefied chlorine and summon the doctor for further treatment.

- If chlorine has entered the eye

  Immediately wash the eye with water keeping the water running for 15 or more minutes and summon the doctor for further treatment.

- Measures during leakage of chlorine gas

  Wear protective gear such as breathing apparatus. Before checking the leakage locations, wear protective gear and spray ammonia. Leakage is indicated at the location where white fumes are emitted.

  Roll leaking cylinders into the neutralization pit.

  Thereafter, request experts to repair the leaking equipment.

- If there is an unexpected leakage and a possibility that the scope of danger may expand.
  Contact the relevant department based on the contact system drawing in an emergency determined beforehand.

  If necessary, notify personnel nearby, and evacuate them to the windward side.

  At the same time, neutralize the leaked gas.

9.5.4 ARTIFICIAL RESPIRATION

Artificial respiration may be carried out to revive a person whose heart has stopped. The procedure for cardiopulmonary resuscitation (CPR) is given below.

- Check consciousness
- Ensure air passage is satisfactory
- Check breathing
- Start artificial respiration
- Check for signs of circulation
- Heart massage
- Cardiopulmonary resuscitation (CPR)

Source: JSWA, 2003

APPENDIX B.9.6 SEWAGE TREATMENT PLANT ACCIDENT REPORT

Table B9.6-1 Sewage treatment plant accident report

SEWAGE TREATMENT PLANT ACCIDENT REPORT

Date of this report Name of person injured

Date of injury Time Occupation

Home address

Age sex Check First aid case or disabling(lost time)injury

Employee or staff injury on duty or Off duty Visitor injury

Date last worked Date returned to work

Person reporting

DESCRIPTION OF ACCIDENT

1. Description of Accident (Describe in detail what happened) (Name machine, tool, appliance, part, gears, pulley, etc.):
2. Accident occurred where? If vehicle accident, make simple sketch of scene of accident.
3. Describe nature of injury and part of body affected (Amputation of finger laceration of leg, back strain, etc.):
4. Were other persons involved? (If yes, give names and addresses)
5. Names and addresses of witnesses.
6. If property damage involved, give brief description.
7. Name and address of physician.
8. Treatment given for injures

Source: EPA, 2008

APPENDIX B.10.1 MECHANICAL CLEANING OF SEPTIC TANKS

The requirement of suction machines for emptying septic tanks in the towns where septic tanks exists (full or partial) for a specified population is calculated based on the following assumptions.

1. No. of households in a town having population of 1 Lac (@ 5 persons in an household) - 20000 household i.e. 20000 Septic tanks
2. Septic tanks need to be cleaned once in 2 years. Hence the requirement septic tanks to be cleaned per year will be about 10000.
3. To clean 10000 septic tanks in a year, the requirement of lorries is 8 numbers
4. Septic tank cleaning is by ordinary vacuum tugs which can hold only 6000 liters maximum. The regular jet rodding cum suction machines must not be used for septic tank cleaning because the jet rodding portion of the machine is wasted. As such 10,000 septic tanks to be cleaned means sewer lorries (not jet rodding cum suction machines) shall alone be used. Cost wise 5 such sewer lorries can be purchased instead of a single jet rodding cum suction machine.

• Number of septic tanks to be cleaned	10,000
• Size of a typical septic tank	2m * 1m * 1.2m
• Volume to be sucked out	2.5 cum
• Sewer lorry capacity	6 cum
• Number of septic tanks that can be cleaned in one trip	2 numbers
• Time taken for onward, suction and return	4 hours
• Hours available for day shift	8 hours
• Number of trips per day per lorry	2 trips
• Number of septic tanks sucked out per day per lorry	2*2 = 4 numbers
• Lorry maintenance and down time days per year	30 days
• Effective days per year per lorry	365-30=335 days
• Number of septic tanks sucked by lorry per year	335*4 = 1340
• Number of lorries needed per year	10000 / 1340 = 8 lorries

Sewer lorries are to be barred from operating in other than general shifts because the noise nuisance it will create to the neighbours in the night and the risk of the lorry operator discharging surreptitiously in the nights at various places plus security concerns.

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