## FOREWORD

The water quality management in our country is performed under the provisions of Water (Prevention and Control of Pollution) Act, 1974. The basic objective of Water (Prevention & Control of Pollution) Act 1974 is to maintain and restore the wholesomeness of all aquatic resources by prevention & control of pollution. For management of water quality of a water body, one has to define the water quality requirements or water quality objectives for that water body. Pollution control or its abatement can be effectively implemented if reliable data on the levels of pollution is available. Thus monitoring of environmental pollution at site and their subsequent analysis is imperative.

The Andhra Pradesh/Telangana Pollution Control Board is actively participating in the "National Water Quality Monitoring Programme" in collaboration with Central Pollution Control Board since 1980. All the major, medium, minor rivers, lakes, tanks and ground water resources of Andhra Pradesh/Telangana states are being monitored under various programmes like GEMS, MINARS, GAP, Action Plan, etc. at more than 150 sampling locations.

An Act to provide for the protection and improvement of environment and for matters connected there with.

WHEREAS the decisions where taken at the United Nations Conference on the Human Environment held at Stockholm in June, 1972, in which India participated, to take appropriate steps for the protection and improvement of human environment.

AND WHEREAS it is considered necessary further to implement the decisions aforesaid in so far as they relate to the protection and improvement of environment and prevention of hazards to human beings, other living creatures, plants and property;

## INTRODUCTION

The Single most important item standing between design performance success or failure is OPERATION or ultimately the OPERATOR. An Operator aware of the Treatment Scheme & Process can derive the best solutions for the day to day problems and emergency situations. This operation and maintenance manual (O & M manual) is intended to guide potential operator/user on how best to obtain optimum performance from Effluent Treatment Plants.

The basic requirements of successful Operation and maintenance of S.T.P are

- A thorough knowledge of Plant, machinery and equipment's provided in the Plant and their functions.
- A thorough Knowledge of the Processes.
- Adequate tools
- Systematic and periodic inspection and maintenance of Plant and machinery.
- Strict adherence to maintenance schedules.
- Good housekeeping.
- Proper logging of all operation and maintenance activities.

In this Manual an attempt has been made to briefly describe the System. The initial two chapters are entirely devoted to Basic Engineering and detailed engineering of the S.T.P.. We believe that understanding the fundamentals of the Activated Sludge Process would enable the Operator to acknowledge and follow the Operation procedures religiously.

The Operation and Maintenance Procedures are best illustrated in two separate chapters. The Operation procedures are described unit wise for clarity.

Comments and suggestions to improve upon this O&M manual will be greatly appreciated.

CHAPTER 1

# STP BASIC ENGINEERING

Sewage Treatment Plant installed at **M/s. Aparna Lake Breeze ., Hyderabad**. Supplied by **M/s. *REVOLVE ENGINEERS Pvt Ltd.,*** is to treat Sewage/Effluent generated from the Commercial, Housing, Industrial facilities of the organization.

The Sewage treatment plant is designed to treat daily Effluent quantity of 935 Kilo Liter's per day (KLD) The parameters based on which the S.T.P. has been designed are provided in the next article.

## 1. General Background

Activated sludge process, oxidation ponds, aerated lagoons and oxidation ditches are the commonly adopted suspended growth biological treatment systems. Compared to the pond and lagoon systems, activated sludge systems also lend themselves for a number of design and operational control measures to improve performance and achieve desired treated wastewater quality. However, the flexibility in design and process control for these systems comes at the cost of high external energy inputs and skilled operation requirements.

Conventional activated sludge process (ASP) is not designed to remove nitrogen. Further, due to its short detention time, the sludge produced is not well digested warranting an additional sludge digestion treatment. A modification of the conventional activated sludge process has made the emergence of the sequencing batch reactor (SBR) process. Conventional ASP systems are space oriented. Wastewater flow moves from one tank into the next on a continuous basis and virtually all tanks have a predetermined liquid volume. The SBR, on the other hand, is a time-oriented system, with flow, energy input, and tank volume varying according to some pre-determined, periodic operating strategy. Hence, SBR is best defined as a time-oriented, batch process, falling under the broad category of an unsteady-state activated sludge system.

Current interest in sequencing batch treatment of wastewater would appear to be a return to the original notion of the activated sludge process. Interest in the SBR has endured and work has extended to the use of SBR for nutrient removal and for the treatment of industrial and hazardous wastes. In this paper, a review on the principles, design, and operation with some case studies of SBR system is provided.

**Effluent Flow rates:**

The rate of Effluent generation is estimated to be 935 cubic meters per day. Design values of maximum, minimum and average flow rates are mentioned below.

Quantity per Day : 935 M3/Day.

Inlet Characteristics:

| Parameters | Unit | Range |
|---|---|---|
| Nature of Waste | | Sewage |
| Flow | M3/day | 935 |
| Ph | -- | 6.5 – 8.5 |
| $BOD_5$ | mg/l | 250-350 |
| COD | mg/l | 600-800 |
| Total Suspended Solids (TSS) | mg/l | 400 |
| Oil & Grease | mg/l | Upto 50 |
| E coil | MPN | 10 |
| Odour | | odourless |
| Color | | colorless |

Quality of Treated Water

| Parameters | Unit | Range |
|---|---|---|
| Ph | -- | 6.5 – 8.5 |
| $BOD_5$ | mg/l | <10 |
| COD | mg/l | < 60 |
| Suspended Solids | mg/l | < 10 |
| Oil and Grease | mg/l | < 10 |
| E coil | | Nil |

### 1.2. The SBR Technology for Wastewater Treatment

In its most basic form, the SBR system is simply a set of tanks that operate on a fill-and-draw basis. The tanks may be an earthen or oxidation ditch, a rectangular basin, or any other concrete/ metal type structure. Each tank in the SBR system is filled during a discrete period of time and then operated as a batch reactor. After desired treatment, the mixed liquor is allowed to settle and the clarified supernatant is drawn from the tank. The essential difference between the SBR and the conventional continuous flow activated sludge system is that SBR carries out functions such as equalization, aeration and sedimentation in a time rather in a space sequence.

One advantage of the time orientation of the SBR is flexibility of operation. The total time in the SBR is used to establish the size of the system and can be related to the total volume of a conventional continuous-flow facility. As a result, the fraction of time devoted to a specific function in the SBR is equivalent to some corresponding tank in a space oriented system. Therefore, the relative tank volumes dedicated to, say, aeration and sedimentation in the SBR can be redistributed easily by adjusting the mechanism which controls the time (and, therefore, share the total volume) planned for either function. In conventional ASP, the relative tank volume is fixed and cannot be shared or redistributed as easily as in SBR.

Because of the flexibility associated with working in time rather than in space, the SBR can be operated either as a labor-intensive, low-energy, high sludge yield systems or as an energy-intensive, low-labor, low sludge yielding system for essentially the same physical plant. Labor, energy and sludge yield can also be traded off with initial capital costs. The operational flexibility also allows designers to use the SBR to meet many different treatment objectives, including one objective at the time of construction (e.g. BOD and suspended solids reduction) and another at a later time (e.g. nitrification/de-nitrification in addition to BOD and suspended solids removal)

Primary Units

The first unit of Primary treatment is the Inlet Chamber, in which the discharge from Common rising main through Raw Sewage Pumps is received. The inlet chamber is mainly used to control the velocity of raw influent and also for its smooth distribution of flow to the fine screen channel. The fine screen channel will be equipped with manual screen & mechanical screen as required designed for peak flow velocity. Necessary hand operated sluice gate shall be provided at upstream of the chamber to isolate the screen when it is under maintenance. The screenings is conveyed to the disposal through a belt conveyor and further it is to be disposed off by suitable arrangement. The screened influent then flows to the Grit chambers where the heavy inorganic matter is separated. The Grit free waste thus obtained will flow to SBR basin. At this stage physical treatment of raw influent known as Primary Treatment completes.

### 1.3 SBR Process:

SBR is a ***SEQUENTIAL BATCH REACTOR*** process. It provides highest treatment efficiency possible in a single step biological process.
SBR– System is operated in a batch reactor mode which eliminates all the inefficiencies of the continuous processes. A batch reactor is a perfect reactor, which ensures 100% treatment. Two
Modules are provided to ensure continuous treatment. The complete process takes place in a single reactor, within which all biological treatment steps take place sequentially. NO additional settling unit / secondary clarifier is required! The complete biological operation is divided into cycles. Each cycle is of 3 – 5 hrs duration, during which all treatment steps take place.

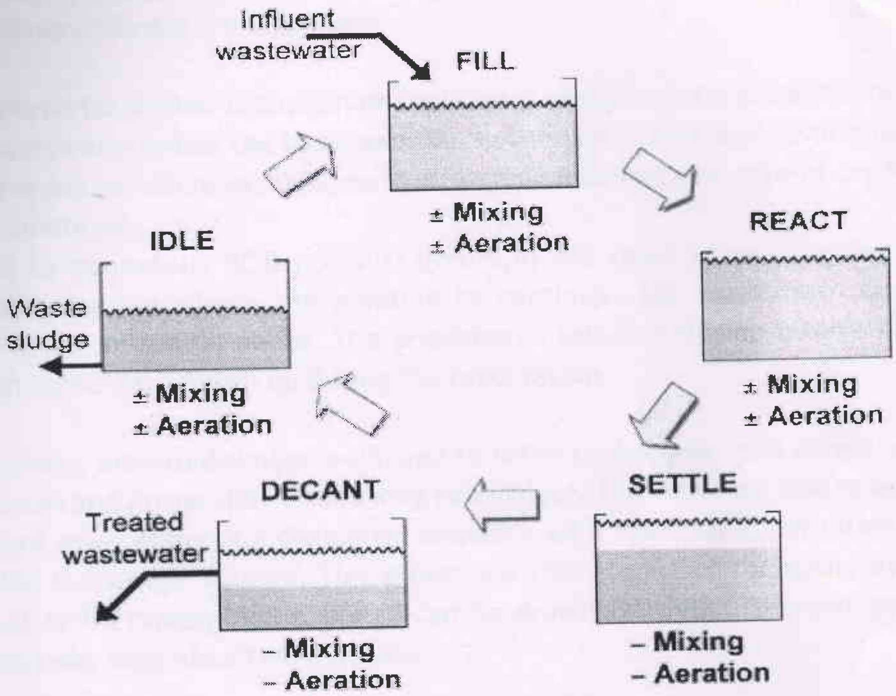
#### Raw Sewage Pumping Station

As per the requirement of the plant, the Raw Sewage Pumping Station is designed to handle average, peak and lean flows. The Coarse Screen Chamber is provided ahead of sump. Screens will be provided in the Coarse Screen Chamber to screen the raw influent. Necessary hand operated Bar Screen shall be provided to isolate t he screen when it is under maintenance. The
Screened sewage is then allowed to flow to the Raw Sewage Collection Sump. The detention time stipulated as per the tender is adopted for the hydraulic design of wet well. The necessary pumps will be provided to pump the screened raw sew age for further treatment.

The common rising main is provided to carry the sewage from raw sewage sump to Primary units

Sequencing batch reactor (SBR) is a fill-and-draw activated sludge treatment system. Although the processes involved in SBR are identical to the conventional activated sludge process, SBR is compact and time oriented system, and all the processes are carried out sequentially in the same tank. SBR system is the upgraded version of the conventional activated sludge process, and is capable of removing nutrients from the wastewater. This paper reviews the fundamentals of the SBR process, design concept, operational and maintenance aspects, and case studies.

## 1.4 Sequencing Batch Reactor Design and Operational Considerations




Major Phases of the SBR operational cycle

## 1.5 Basic Treatment Process

The operation of an SBR is based on fill-and-draw principles, which consists of five steps—fill, react, settle, decant, and idle. These steps can be altered for different operational applications.

**Fill** – During the fill phase, the basin receives influent wastewater. The influent brings food to the microbes in the activated sludge, creating an environment for biochemical reactions to take place. Mixing and aeration can be varied during the fill phase to create the following three different scenarios:

***Static Fill*** – Under a static-fill scenario, there is no mixing or aeration while the influent wastewater is entering the tank. Static fill is used during the initial start-up phase of a facility, at plants that do not need to nitrify or denitrify, and during low flow periods to save power. Because the mixers and aerators remain off, this scenario has an energy-savings component.

***Mixed Fill*** – Under a mixed-fill scenario, mechanical mixers are active, but the aerators remain off. The mixing action produces a uniform blend of influent wastewater and biomass. Because there is no aeration, an anoxic condition is present, which promotes de-nitrification. Anaerobic conditions can also be achieved during the mixed-fill phase. Under anaerobic conditions the biomass undergoes a release of phosphorous. This release is reabsorbed by the biomass once aerobic conditions are reestablished. This phosphorous release will not happen with anoxic conditions.

***Aerated Fill*** – Under an aerated-fill scenario, both the aerators and the mechanical mixing unit are activated. The contents of the basin are aerated to convert the anoxic or anaerobic zone over to an aerobic zone. No adjustments to the aerated-fill cycle are needed to reduce organics and achieve nitrification. However, to achieve de-nitrification, it is necessary to switch the oxygen off to promote anoxic conditions for de-nitrification. By switching the oxygen on and off during this phase with the blowers, oxic and anoxic conditions are created, allowing for nitrification and de-nitrification. Dissolved oxygen (DO) should be monitored during this phase so it does not go over 0.2 mg/L. This ensures that an anoxic condition will occur during the idle phase.

**React**

This phase allows for further reduction or "polishing" of wastewater parameters. During this phase, no wastewater enters the basin and the mechanical mixing and aeration units are on. Because there are no additional volume and organic loadings, the rate of organic removal increases dramatically.

Most of the carbonaceous BOD removal occurs in the react phase. Further nitrification occurs by allowing the mixing and aeration to continue—the majority of de-nitrification takes place in the mixed-fill phase. The phosphorus released during mixed fill, plus some additional phosphorus, is taken up during the react phase.

**Settle**

During this phase, activated sludge is allowed to settle under quiescent conditions—no flow enters the basin and no aeration and mixing takes place. The activated sludge tends to settle as a flocculent mass, forming a distinctive interface with the clear supernatant. The sludge mass is called the sludge blanket. This phase is a critical part of the cycle, because if the solids do not settle rapidly, some sludge can be drawn off during the subsequent decant phase and thereby degrade effluent quality.

**Decant**

During this phase, a decanter is used to remove the clear supernatant effluent. Once the settle phase is complete, a signal is sent to the decanter to initiate the opening of an effluent-discharge valve. There are floating and fixed-arm decanters. Floating decanters maintain the inlet orifice slightly below the water surface to minimize the removal of solids in the effluent removed during the decant phase. Floating decanters offer the operator flexibility to vary fill and draw volumes. Fixed-arm decanters are less expensive and can be designed to allow the operator to lower or raise the level of the decanter. It is optimal that the decanted volume is the same as the volume that enters the basin during the fill phase. It is also important that no surface foam or scum is decanted. The vertical distance from the decanter to the bottom of the tank should be maximized to avoid disturbing the settled biomass.

### Idle

This step occurs between the decant and the fill phases. The time varies, based on the influent flow rate and the operating strategy. During this phase, a small amount of activated sludge at the bottom of the SBR basin is pumped out—a process called wasting.

### 1.6 Continuous-Flow Systems

SBR facilities commonly consist of two or more basins that operate in parallel but single basin configurations under continuous-flow conditions. In this modified version of the SBR, flow enters each basin on a continuous basis. The influent flows into the influent chamber, which has inlets to the react basin at the bottom of the tank to control the entrance speed so as not to agitate the settled solids. Continuous-flow systems are not true batch reactions because influent is constantly entering the basin. The design configurations of SBR and continuous-flow systems are otherwise very similar. Plants operating under continuous flow should operate this way as a standard mode of operation. Ideally, a true batch-reaction SBR should operate under continuous flow only under emergency situations. Plants that have been designed as continuous-inflow systems have been shown to have poor operational conditions during peak flows. Some of the major problems of continuous-inflow systems have been overflows, washouts, poor effluent, and permit violations.

CHAPTER 2

# DESIGN GUIDELINES

## 2. Technical specification of Equipment's

| SL.No. | ITEM | TECHNICAL SPECIFICATIONS | QTY |
|---|---|---|---|
| 1-3. | Bar Screen | **Fine Screen:**<br>Size : 1000mm* 600mm<br>Opening : 10mm<br>MOC : SS<br>Make : REPL<br>**Fine Screen:**<br>Size : 1000mm* 600mm<br>Opening : 8 mm<br>MOC : SS<br>Make : REPL<br>**Fine Screen:**<br>Size : 1000mm* 600mm<br>Opening : 6 mm<br>MOC : SS<br>Make : REPL | 3 Nos |
| 4. | Raw sewage pumps | Type : Submersible,Centifugal<br>Capacity : 100 KLH<br>Head : 9 mtrs;<br>Particle Handling: 50mm<br>MOC : CI<br>Motor Rating : 4 KW<br>Make : Grundfos<br>Model No : SL1.80.80.40.4.51D | 2 Nos |
| 5. | Accessories for Raw Sewage Transfer Pumps | Auto couplings, Lifting chain, Guide Rails &Intermediate Guide Rails. | 2 Sets. |
| 6. | Return Sludge Transfer pumps for SBR1&SBR2 | Type : Submersible,Centifugal<br>Capacity : 20 KLH<br>Head : 9 mtrs;<br>Particle Handling: 50mm<br>MOC : CI<br>Motor Rating : 1.1 KW<br>Make : Grundfos<br>Model No : SL1.50.65.11.2.50B | 4 Nos |

| SL.No. | ITEM | TECHNICAL SPECIFICATIONS | QTY |
|---|---|---|---|
| 7. | Air Blowers for SBR1 &SBR2 | Type : Twin Lobe compressor consist of V-belt, Drive and Driven Pulleys<br>Capacity : 690 CUM/HR at 0.65 kg/cm2<br>MOC : Cast Iron<br>Drive : Belt Driven Type<br>Accessories : Base frames, Air filter for suction line and silencer for discharge, safely valve & pr. Gauge, V belt, V belt guard.<br>Make : Everest/Eq<br>Quantity : 1W+1S<br>Model : 610 ET<br>**MOTOR**<br>Type : Horizontal Foot Mounted motor<br>Motor Rating : 30 HP<br>1 Set : 1 W + 1 S,<br>Make : ABB | 1 Set. |
| 8. | Air Blowers for ET &SHT | Type : Twin Lobe compressor consist of V-belt, Drive and Driven Pulleys<br>Capacity : 250 CUM/HR at 0.55 kg/cm2<br>MOC : Cast Iron<br>Drive : Belt Driven Type<br>Accessories : Base frames, Air filter for suction line and silencer for discharge, safely valve & pr. Gauge, V belt, V belt guard.<br>Make : Everest/Eq<br>Quantity : 1W+1S<br>Model : M 5125<br>**MOTOR**<br>Type : Horizontal Foot Mounted motor<br>Motor Rating : 12.5 HP<br>1 Set : 1 W + 1 S,<br>Make : ABB | 1 Set. |
| 9. | Coarse Bubble Diffusers | Type : Coarse Bubble Diffusers<br>Size : 90 mm Dia x 1000 mm Long<br>MOC : PVC<br>Make : Scogen | 26 Nos. |

| SL.No. | ITEM | TECHNICAL SPECIFICATIONS | QTY |
|---|---|---|---|
| 10. | Fine Bubble Diffusers | Type : Fine Bubble<br>Size : 90 mm Dia x 1000 mm Long<br>MOC : EPDM Membrane<br>Make : Scogen | 172 Nos. |
| 11. | Decanting **Mechanism** | Supply, Installation, Testing and commissioning of Heavy Duty piping inside SBR Tanks with manually operated Butterfly valves and with SS mesh at outlet.<br>Make : Intervalve<br>Sizes:200 NB,150NB,100NB | 01Lot |
| 12. | Chlorine **D**osing System | Capacity : 0-12 Lph with manual adjustment<br>MOC : PP<br>Make : Asia LMI<br>Dosing Tank Volume : 100 Ltrs<br>MOC of Tank : HDPE<br>Make : Sintex | 2 Nos |
| 13. | Filter Feed Pumps | Type : Monoblock, Centrifugal<br>Capacity : 33 M3/Hr<br>Head : 30-35 mtrs<br>MOC : CI<br>Model : KDS 837+<br>Motor Rating : 5.5 KW<br>Make : Kirloskar | 4 Nos. |
| 14. | **P**ressure Sand Filter | Type: Vertical Cylindrical<br>Capacity: 33 m3/hr<br>Filtration Velocity: 8 m3/m2/hr<br>Make: REPL<br>Size : 2200mmX1800mm<br>Shell Thickness: 8mm<br>Dish Thickness: 10 mm<br>Design Pressure: 3 Kg/cm2<br>Test Pressure : 5 Kg/cm2<br>Internal Finish: Epoxy Paint<br>External Finish: Anti corrosive Paint<br>Filter Media: Graded sand pebbles of various sizes<br>Qty: 6080 Kg's<br>Accessories: MS "B" Class Frontal Piping wit manual butterfly valves.<br>MOC of the Vessel: MSEP<br>Make : REPL | 2 Nos. |

| SL.No. | ITEM | TECHNICAL SPECIFICATIONS | QTY |
|---|---|---|---|
| 15. | Activated carbon Filter | Type: Vertical Cylindrical<br>Capacity: 33 m3/hr<br>Filtration Velocity: 8 m3/m2/hr<br>Make: REPL<br>Size : 2200mmX1800mm<br>Shell Thickness: 8mm<br>Dish Thickness: 10 mm<br>Design Pressure: 3 Kg/cm2<br>Test Pressure : 5 Kg/cm2<br>Internal Finish: Epoxy Paint<br>External Finish: Anti corrosive Paint<br>Filter Media: Carbon<br>Qty: 2280 Kg's<br>Accessories: MS "B" Class Frontal Piping wit manual butterfly valves.<br>MOC of the Vessel: MSEP<br>Make : REPL | 2 Nos. |
| 16. | Centrifuge Feed Pumps | Type : Grinder system<br>Capacity : 5 M3/Hr<br>Head : 15 mtrs<br>MOC : CI<br>Model : SEG 40.12.2.50B<br>Motor Rating : 1.2 KW<br>Make : Grundfos | 2 Nos. |
| 17. | Centrifuge System with motor | Type : Solid Bowl type centrifuge<br>MOC Of wetted parts: SS 304<br>MOC Of housing: carbon steel<br>Capacity : 5 M3/Hr<br>Make : Hiller | 1 No. |
| 18. | Compressor & compressed Air for filter Backwash | Capacity: 170 Ltrs<br>Make : ELGI/Eq<br>Compressed Air line: SS 304 | 1 Set |
| 19. | UV Sterilizer | Provision to connect nos of UV sterilizers | 2Nos |
| 20. | Flow Meters at each filter outlet | Size: 100 mm<br>Type: Electro mechanical<br>Make: Krohne Marshall | 3Nos. |

| SL.No. | ITEM | TECHNICAL SPECIFICATIONS | QTY |
|---|---|---|---|
| **21.** | Alkanity Dosing System | Capacity : 0-10 Lph with manual adjustment<br>MOC : PP<br>Make : Asia LMI<br>Dosing Tank Volume : 100 Ltrs<br>MOC of Tank : HDPE<br>Make : Sintex | 1No |
| 22. | Poly Dosing System | Capacity : 0-100 Lph with manual adjustment<br>MOC : PP<br>Make : Asia LMI<br>Dosing Tank Volume : 1000 Ltrs<br>MOC of Tank : HDPE<br>Make : Sintex | 1No |
| 23. | Piping ,Fittings, Valves | Supply, Installation, Testing and commissioning all interconnecting piping (PB) within the plant room including<br>MS Piping : Jindal<br>Valves : Intervalve | 1 Lot. |
| 24. | Control Panel | Supply, Installation, Testing and commissioning of suitable compartmental type control panel<br>Make: Power Max | 1 No. |
| 25. | Cable & Cable Trays | Supply, Installation, Testing and commissioning of GI Perforated cable trays with armored cables of Aluminum/Copper<br>Cable make: Poly cab | 1Lot. |

### 2.1 Preliminary/Primary Treatment

Preliminary treatment includes screening, grit removal, and flow monitoring. Primary treatment includes sedimentation and floatation. SBRs generally do not have primary settling tanks; therefore, effective removal or exclusion of grit, debris, plastics, excessive oil or grease, and scum, as well as screening of solids should be accomplished prior to the activated-sludge process.

#### 2.1.1 Screening Influent Wastewater

Bar screens or mechanical screens should be used instead of grinders or shredders.

Screening influent wastewater is a positive means of removing rags, sticks, and other debris before they can enter the treatment process. Grinders and shredders pass this material into the SBR where it can become woven together, making it difficult to remove. Removing debris from the wastewater stream before it reaches the basins is beneficial to both the treatment process and the settling phase—excess debris is not present to interfere with the solids that need to settle, resulting in a high-quality sludge blanket. Screens also provide protection for the pumps.

### 2.1.2 Influent-Flow Equalization

Flow equalization is critical where significant variations in flow rates and organic mass loadings are expected. Flow equalization is also important if a plant is expected to receive a significant amount of septage or is taking in a significant amount of industrial wastes. Flow equalization is strongly recommended when a plant needs to achieve nitrification and de-nitrification. It is important to note, however, that the size of the influent equalization basin must be carefully considered because an oversized basin can cause negative downstream-treatment-process impacts. A plant utilizing an influent equalization basin will be able to have a true batch reaction. Influent-flow equalization benefits the SBR process in the following ways:

• Allows for a smaller SBR-basin size because it allows for storage until the process cycle is complete.
• Allows for one basin to be taken off line for maintenance or for seasonal variations. Routine maintenance is necessary for all tanks. For plants that have seasonal variations, taking one basin off line is cost-effective due to a reduced need for electricity, staff hours, and tank maintenance.
• Allows for scum and grease removal at a single point before it enters the SBR tank. Entrainment by mixing should not be the sole means of scum control. A mechanism or process for removing scum, grease, and floatables should be provided in the equalization tank.
• Allows plants that must denitrify to ensure that an adequate amount of carbon is available in the de-nitrification fill phase.
• Allows for an equal flow volume into the basin, keeping the food to microorganism ratio (F/M) fairly stable. As stated previously, each SBR design is unique and in some situations influent-flow

## 2.2 Sequencing Batch Reactor

### 2.2.1 Basin Design

Ideally, plant designs should have a minimum of two SBR basins and one flow equalization basin; however, every design is unique and one configuration does not fit all situations. All SBR designs should have a minimum of two basins to allow for redundancy, maintenance, high flows, and seasonal variations. Two basins allow for redundancy throughout the plant. If one basin is off line, the plant is still able to treat influent wastewater because of the equalization basin. If the basin microbiology becomes depleted in one basin, the biomass from the remaining basin can be used to restock the basin with depleted biomass. For this to happen, a means of transferring sludge between the two basins must be provided.

During storm events and high-flow periods, instead of bypassing the basins or blending the storm water, an additional basin can act as storage, or certain cycles can be shortened. In particular, the react cycle can be shortened under wet-weather conditions because of the diluted flow and the reduced time needed to treat the BOD. With higher flows, the fill phase and the idle cycle can also be shortened. A two-basin design also allows the plant to take one basin off line for draining and cleaning while the pre-flow basin and the one online basin remain fully operational.

For plants that have seasonal flow variations, a design that includes two treatment basins and an influent-flow-equalization basin allows one basin to be taken off line during the off season. This is important for seasonal plants, as it can save money by cutting electricity costs and reducing staff hours (fewer hours are spent on overall basin maintenance). The basin that remains on line is able to reseed the biomass in the off-line basin when the influent flow pattern peaks.

### 2.2.2 Flow-Paced Batch Operation

Flow-paced batch operation is generally preferable to time-paced batch or continuous inflow systems. Under a flow-paced batch system, a plant receives the same volumetric loading and approximately the same organic loading during every cycle. The SBR basin already has stabilized supernatant in it, which dilutes the batch of incoming influent.

Under a time-paced mode, each basin receives different volumetric and organic loading during every cycle, and the plant is not utilizing the full potential of this treatment method—the ability to handle variable waste streams. After each loading, the plant faces a whole new set of treatment conditions, making the operator's job more difficult.

Time-paced operation (if you are not adjusting the cycle time) can lead to under-treated effluent. A plant that receives heavy morning loadings, with a flow pattern that drops off after the first cycle, must deal with two different biologies in the basin unless adjustments are made to the cycle time. For example, one basin could be receiving an early morning load, which has a high organic and volumetric loading. The second basin could be receiving the afternoon loading, which has a lower organic and volumetric loading. Unless the time cycle is adjusted, it becomes difficult to operate under these conditions because the operator is essentially running two separate plants.

Another problem with time-paced operation is that if the plant is required to denitrify, it may not bring in an adequate carbon source needed for the bacteria to strip oxygen from the nitrate. This scenario would be especially problematic during periods of low flow. For an SBR to be effective, the plant must have proper monitoring, allow operators to adjust the cycle time, and have knowledgeable operators who are properly trained to make the necessary adjustments to the cycle.

### 2.2.3 Blower Design

Several smaller blowers are preferable to one large unit. It is not uncommon for SBR designs to incorporate a single blower per basin to provide aeration. However, operational efficiency can be enhanced when plants utilize several smaller blowers, instead of one large blower.

When a single blower per basin is used, it should be sized to provide maximum aeration under worst-case conditions. These conditions typically occur in the summer months, when higher temperatures decrease the amount of oxygen that can be dissolved in wastewater. For facilities that utilize a single blower per basin, a variable frequency drive should be considered.

In a plant configured with only one blower per basin, it is difficult to scale back on the aeration provided. With multiple smaller blowers, units can be taken off line when maximum aeration is not required. This results in electrical cost savings.

Fine-bubble membrane diffusers are preferable to coarse-air bubble aeration. Fine-bubble diffusers transfer more oxygen to the water due to increased surface area in contact with water. The same amount of air introduced in a big bubble has less surface area in contact with water than an equal amount of air divided into smaller bubbles. The amount of surface area in contact with water is proportional to the amount of oxygen transferred into water. Depth of aerators also plays a part in oxygen transfer, due to contact time. The deeper the aerator, the longer it takes for the bubble to come to the surface. Aerator depth is deepest when a tank is filled to the high-water level. If a plant is utilizing time-paced batch reactions, aerator depth is not optimal and oxygen contact time is not maximized.

Blowers in multiple units should be sized to meet the maximum total air demand with the single largest blower out of service.

### 2.2.4 Decanting

During the decant phase, operating under a flow-paced batch operation, no more than one third of the volume contained in the basin (i.e., the tank contents) should be decanted each time in order to prevent disturbance of the sludge blanket. The decant phase should not interfere with the settled sludge, and decanters should avoid vortexing and taking in floatables. The problem with decanting more than one-third is that it increases the chance that solids will be decanted into the effluent, thereby impairing the effluent quality. For the plant to run optimally, it is important that the decant volume is the same as the volume added during the fill phase. The length of the decant weir can have an impact that is very similar to that of the over-flow weir found in a clarifier. The flux (upward forces) caused by the discharge of the decant creates an upward force that may pull poorly settled solids up and out the discharge.

### 2.2.5 Bottom Slope

All basins should have a sloped bottom with a drain and sump for routine tank maintenance and ease of cleaning. Slope rectangular basins slightly to one corner to allow for hosing down the unit. Circular basins should be sloped toward the middle for maintenance. All SBR designs should include a means for completely emptying each SBR unit of all grit, debris, liquid, and sludge.

# CHAPTER 3
# OPERATIONAL SUGGESTIONS

## 3.1 Parameters to Be Monitored

Oxidation reduction potential (ORP), dissolved oxygen (DO), pH, and alkalinity are parameters that should be monitored by the Supervisor. Manufacturers determine what parameters can be monitored and controlled by the system. Monitoring of certain parameters is important, and the ability to adjust these parameters from a remote location is ideal. The operator needs to be able to add chemicals to raise the alkalinity and subsequently the pH. The set point should be an alkalinity value rather than pH based.

The operator should have the ability to fully control (i.e., modify) the plant-operating parameters, such as (but not limited to) cycle times, volumes, and set points.

Alkalinity monitoring and addition ensures that a pH of less than 7.0 does not occur. Nitrification consumes alkalinity, and with a drop in alkalinity, pH also drops. If a plant has adequate alkalinity, pH does not change, so it does not need to be raised. Chemicals that raise alkalinity, such as sodium bicarbonate and soda ash, are recommended over sodium hydroxide. Sodium hydroxide does not raise alkalinity; it does raise pH. for a discussion of the pros and cons of various chemicals used to increase alkalinity.

For plants that nitrify and denitrify, ORP monitoring is desirable. ORP is the measure of the oxidizing or reducing capacity of a liquid. DO varies with depth and location within the basin. ORP can be used to determine if a chemical reaction is complete and to monitor or control a process.

Operators need the ability to make changes that will modify these readings to achieve appropriate nutrient removal. ORP readings have a range and are site specific for each facility. General ranges are: carbonaceous BOD (+50 to +250), nitrification (+100 to +300), and de-nitrification (+50 to -50).

On-line dissolved oxygen meters are very useful in SBR operation. They allow operators to adjust blower times to address the variable organic loads that enter the plant. Lack of organic strength reduces the react time during which aeration is needed to stabilize the wastewater. DO probes can be used to control the aeration-blower run time during the cycle, which in turn reduces the energy cost of aeration.

## 3.2 Sampling

### 3.2.1 Proper Sampling Points

As with all wastewater treatment plants, SBR samples are collected and analyzed for both process control and compliance reporting. Sampling locations must be carefully considered. SBRs that utilize influent-equalization basins have more representative flow spaced composite samples because the discharge is consistent in volume. In other words, flow equalization and true batch reactions allow for easier composite sampling because the same volume is entering and exiting the basin during each cycle.

Twenty-four-hour effluent composite samples should be flow-paced and include samples collected at the beginning and end of each decant event.

### 3.2.2 Parameters to Monitor

Numerous parameters can be monitored for process control. Testing and monitoring of process control parameters requires planning and organization so that variances from the targeted performance goals are easily recognized. A list of typical process control parameters is provided in Appendix A.

### 3.3 Solids Retention Time – SRT

Solids retention time is the ratio of the mass of solids in the aeration basin divided by the solids exiting the activated sludge system per day. Exiting solids are equal to the mass of solids wasted from the system plus the mass of solids in the plant effluent.

Ensuring an adequate SRT is very critical to the SBR biological nutrient-removal design process. The design SRT for nitrifying systems should be based on the aeration time during the cycle, not the entire cycle time.

### 3.4 Sludge Wasting

Sludge wasting should occur during the idle cycle to provide the highest concentration of mixed liquor suspended solids (MLSS). The plant should be operated on pounds of MLSS and not concentration.

Sludge from the SBR basins can be wasted to a digester and/or holding tank for future processing and disposal. The digester-tank and sludge-holding-tank capacity should be sized appropriately, based on the sludge treatment and disposal method.

Supernatant from the sludge digester and/or holding tank should be returned to the head works or influent equalization basin so that it will receive full treatment. The facility should be designed so that the supernatant volume and load do not adversely affect the treatment process.

A high-level alarm and interlock should be provided to prevent sludge-waste pumps from operating during high-level conditions in the digester and/or holding tanks. Controls should be provided to prevent overflow of sludge from digester tanks and/or holding tanks.

Controls should be provided to prevent overflow of sludge from digester tanks and/or holding tanks.

CHAPTER 4

# OPERATIONAL MAINTENANCE

## Pumps

Pumps must be monitored regularly, correctly and accurately according to a specific plan which is made by a specially trained personnel. The following six parameters should be regularly monitored to understand how a pump is performing:

1. Suction pressure (Ps)
2. Discharge pressure (Pd)
3. Flow (Q)
4. Pump speed (N)
5. Pump efficiency (η)
6. Power.

The advantages regular monitoring of the pumps are -

1. No dismantling of the pump is necessary.
2. Offers cost savings and energy savings by increasing the pump availability and reliability coefficients for pumps.
3. The time to maintain the pump set maybe predicted and planned more accurately and in a qualified manner in line with predictive and planned maintenance strategies.
4. If a flow meter is installed to measure process liquid flow, then the pump monitor is able to verify the accuracy of the meter readings by calculating 'Q' from the empirical formula for power 'P'.

In addition, it is very important to monitor some other conditions for centrifugal pump during normal operation such as:-

1. Vibration monitoring.
2. Oil level and schedule oil Analysis

### Routine inspections

Perform the following tasks whenever you check the pump during routine inspections:

- Check the level and condition of the oil through the sight glass on the bearing frame.
- Check for unusual noise, vibration, and bearing temperatures.
- Check the pump and piping for leaks.
- Analyze the vibration.
- Inspect the discharge pressure.
- Inspect the temperature.
- Check the seal chamber and stuffing box for leaks.
- Ensure that there are no leaks from the mechanical seal.
- Adjust or replace the packing in the stuffing box if you notice excessive leaking.

Three-month inspections

Perform the following tasks every three months:

• Check that the foundation and the hold-down bolts are tight.

• Check the mechanical seal if the pump has been left idle, and replace as required.

• Change the oil every three months (2000 operating hours) at minimum.

• Change the oil more often if there are adverse atmospheric or other conditions that might contaminate or break down the oil.

• Check the shaft alignment, and realign as required.

Annual inspections

Perform the following inspections one time each year:

• Check the pump capacity.

• Check the pump pressure.

• Check the pump power.

If the pump performance does not satisfy your process requirements, and the process requirements have not changed, then do the following:

1. Disassemble the pump
2. Inspect it.
3. Replace worn parts.

**Routine maintenance (Can be made during pump operation)**

Perform the following tasks whenever you perform routine maintenance:

- Clean bearing bracket from any oil if found.
- Check oil drain plug.
- Lubricate the bearings.
- Inspect suction and discharge flanges for any leak.
- Inspect pump casing for any unusual damage signs.
- Inspect the seal.
- If the pump is offline check the coupling and its shims for any damage.
- Make sure that the coupling guard s well tightened to pump base plate.
- Check that motor alignment bolts are all in place.

## Blower operating checks

- **Daily checks –**

  With the blower running, check: Outlet temperatures.

  • Discharge pressure (when functioning under pressure).

  • Suction pressure (when functioning in vacuum conditions).

  • Absorbed power.

- **Check after first 50 hours**

  With the blower shut down, check: The oil level.

  • Oil leaks.

  • Auxiliary circuit leaks.

  • Belt tension.

- Check every 500 hours

  With the blower shut down, check: The oil level.
  - Oil viscosity and condition.
  - Belt wear.
  - Flexible coupling inserts.
  - Auxiliary circuits.

Safety in the Plant:

The work of an Operator in a S.T.P. Presents many hazards that must be guarded against. Common type of accidents are injuries from falls, deaths from drowning and asphyxiation. Narrow walks, steps and platforms over tanks should be used carefully particularly in darkness, rains and wind.

# TROUBLE SHOOTING

## PUMPS Defects and their Possible Causes

| Defect | Possible Causes |
|---|---|
| No Discharge | 1. Pump not properly primed.<br>2. Leakage in Foot valve, Suction Pipe or Gland.<br>3. Hump in suction line.<br>4. Wrong direction of rotation.<br>5. Blockage in strainer, Pipes or in pump.<br>6. Low drive speed (Low voltage).<br>7. Head too high for the pump.<br>8. Suction lift too high. |
| Loss of delivery or Insufficient Discharge | 1. Leakage in suction pipe and glands.<br>2. Foot valve uncovered or inadequately submerged.<br>3. Suction lift high. |
| Excess Power | 1. Too high speed.<br>2. Pump strained by pipes.<br>3. Head too low. |
| Noise & Vibration | 1. Too high delivery.<br>2. Too high suction ift.<br>3. Blocked suction tine or impeller.<br>4. Air entrained in the water.<br>5. Worn or defective Bearing. |

## BLOWERS MAINTENANCE

| SYMPTOM | SYMPTOM PROBLEMS CAUSE | REMEDY |
|---|---|---|
| No Air flow | Speed too low.<br>Wrong direction of rotation.<br>Obstruction in piping. | Check speed and verify as per recommendations.<br>Check for correct direction of rotation.<br>Check suction and discharge line for any obstruction. |
| Low capacity | Speed too low.<br>Excessive pressure.<br>Discharge line leaks. | Check speed, belt drive slippage.<br>Check the line pressure.<br>Check up for open flow path. |
| Excessive power consumption of blower | Speed too high.<br>Differential pressure across the suction and discharge openings too high<br>Impellers rubbing. | Correct the speed.<br>Check line pressure with rated pressure.<br>Check & clean filter and silencer Check for any obstruction in the suction and discharge line.<br>Check the impellers for any hot spots/rubbing marks. If observed, reset impeller timing. This operation requires skill and patience. If in doubt, contact |

| | | |
|---|---|---|
| | | "EVEREST". |
| Overheating of bearings and gears / blower | Inadequate lubrication.<br><br>Differential pressure across the suction and discharge openings too high<br><br>Coupling misalignment<br>Belt slippage/Over tightened belts.<br>Too much oil in gear case<br>Worn impeller, clearances too high<br>Internal contact. | Check for oil level and replace dirty oil.<br><br>Check line pressure with rated pressure. Check & clean filter and silencer. Check for any obstruction in the suction .. and discharge line<br><br>Check alignment and realign.<br>Adjust belt tension.<br><br>Correct oil level.<br>Replace impellers.<br><br>Reset clearances. |
| Vibration | Drive misalignment.<br>Impeller rubbing (Distant knocking sound would be observed).<br><br>Worn bearings/gears.<br>Loose pulley/coupling. | Check alignment.<br>Check for hot points. Recheck blower alignment and mounting, Recheck impeller timing.<br><br>Check and replace the bearings/gears.<br>Check if pulley/coupling is loose on shaft. Check key. |
| Blower jams after running for a short period | Insufficient axial clearances<br><br>Differential pressures across suction & discharge high, resulting in over heating & subsequent jamming, due to thermal expansion | Correct clearances.<br><br>Correct differential pressures. |
| Blower makes heavy knocking sound on running | Unit out of time.<br><br>Distortion due to improper mounting or pipe strains.<br>Differential pressure across the suction and discharge openings too high.<br><br>Worn bearings/gears | Retime impellers.<br><br>Check mounting alignment and relieve pipe strains.<br>Check gauge readings across the suction and discharge ends<br><br>Check and replace the bearings/gears. |
| Oil leaking out of oil fill hole | Excessive oil level.<br>Oil seal leakage | Correct oil level.<br>Check and replace gear end oil seals.. |
| Traces of oil in blower casing | Oil seal leakage. | Check and replace oil seals. |

## APPENDIX A

### MAINTENANCE SHEDULE

| Sl No | Name of the Part | Maintenance to be carried out | TIME | Remarks |
|---|---|---|---|---|
| 1 | Bearings | Checking of Temperature with thermometer | Two months | Hot ball or roller bearings point to too much oil or grease. Hot sleeve bearings need more oil or heavier lubricant. If does not correct, dissemble and inspect the bearing alignment of pump and driver. |
| 2 | Glands | Changing of Gland packing | Two months | |
| 3 | Bearings | Lubrication (greasing) | Two months | Check for saponification resulting in whitish color. Washout with kerosene. |
| 4 | Gauges | Checking of pressure and vacuum gauges. | Three months | |
| 5 | Valves | Changing of gland packing in delivery sluice valve , suction valves, bye pass valve. Reflux valve. | Six months | |
| 6 | Exhaust pump and its auxiliaries. | Checking of gland packing & its auxiliaries etc. | Six months | |
| 7 | Impeller. | Checking of impeller blades. Sleeves efficiency rings, bearings necking impeller nut etc. | One Year | |

## Appendix B
# Process Control Tests and Calculations

The following Process Control Tests and Calculations chart was obtained, with permission, from the Pollution Control Board, Sequencing *Batch Reactor Operations and Troubleshooting Manual.*

**Acronyms Used:**

| | |
|---|---|
| COD | Chemical Oxygen Demand |
| BOD | Biochemical Oxygen Demand |
| CBOD | Carbonaceous Biochemical Oxygen Demand |
| TOC | Total Organic Carbon |
| MLSS | Mixed-Liquor Suspended Solids |
| MLVSS | Mixed-Liquor Volatile Suspended Solids |
| MCRT | Mean Cell Residence Time |
| WAS | Waste-Activated Sludge |
| F/M | Food-to-Microorganism Ratio |
| SSV | Settled-Sludge Volume |
| TSS | Total Suspended Solids |
| VSS | Volatile Suspended Solids |
| DOB | Depth of Blanket |
| SVI | Sludge Volume Index |
| NO3-N | Nitrate-Nitrogen |
| NO2-N | Nitrite-Nitrogen |
| NH3-N | Ammonia-Nitrogen |
| PO4-P | Phosphate-Phosphorus |
| OUR | Oxygen-Uptake Rate |
| SOUR | Specific Oxygen-Uptake Rate |
| ORP | Oxidation Reduction Potential |
| Mg/L | milligram per liter |

# PROCESS CONTROL TESTS AND PROCESS CALCULATIONS

| | DATA REQUIRED/ ANALYSIS | | | UNIT |
|---|---|---|---|---|
| **ORGANIC LOADING** | | | | |
| COD | Colorimetric analysis | | | mg/L |
| BOD, CBOD | Bioassay | | | mg/L |
| TOC | Colorimetric analysis | | | mg/L |
| **SOLIDS INVENTORY** | | | | |
| MLSS | Gravimetric analysis | | | mg/L |
| MLVSS | Gravimetric analysis | | | mg/L |
| Centrifuge Spin | Volumetric analysis | | | % |
| | | | | |
| **SOLIDS INVENTORY CALCULATIONS** | | | | |
| MCRT | MLSS | WAS TSS | WAS Flow | days |
| Sludge Age | AT% | CL% | WAS% | days |
| F/M | MLVSS | #BOD/COD/day | #BOD/COD/day | #MLVSS |
| | | | | |
| **SLUDGE QUALITY** | | | | |
| SSVX | Physical analysis | | | ml/L or % |
| SSV5 | SSV5 Physical analysis | | | |
| Supernatant or Turbidity | Gravimetric or scattered light | | | mg/L or NTU |
| DOB | Physical measurement | | | ft |
| Microscopic Analysis | Visual analysis | | | N/A |
| **SLUDGE QUALITY CALCULATIONS** | | | | |
| SVI SSV30 MLSS ml/g | SSV30 | MLSS | | ml/g |
| | | | | |
| **NUTRIENTS** | | | | |
| NO3-N, NO2-N | Colorimetric or electrometric analysis | | | mg/L |
| NH3-N | Colorimetric or electrometric analysis | | | mg/L |
| PO4-P | Colorimetric analysis | | | mg/L |
| | | | | |
| **TROUBLESHOOTING ANALYSES** | | | | |
| OUR | OUR Analysis | | | mg O2/L/hr |
| SOUR | OUR | MLVSS | | mg O2/g/hr |
| Ph | Electrometric analysis | | | SU |
| ORP | Electrometric analysis | | | mV |
| Alkalinity | Titrimetric analysis | | | mg/L |

| | | | | |
|---|---|---|---|---|
| | | | | increase MCRT. |
| | B. High effluent NH3 – N (Incomplete nitrification | Influent and process NH3 –N, influent and process alkalinity, pH, temperature, SOUR, D.O. | • Influent NH3-N overload | • Increase aerobic cycle. |
| | | | • Low D.O. | • Increase aerobic cycle. |
| | | | • Low temperature | • Increase aerobic cycle. |
| | | | • Inadequate aerobic retention time | • Increase aerobic cycle. |
| | | | • Low pH or alkalinity | • Add alkalinity. |
| | | | • Low MLVSS (nitrifiers) | • Increase MLVSS. |
| | | | • Toxicity | • Isolate or split flow, identify source of toxic influent and eliminate,increase aeration cycle, increase MCRT. |
| **IV.** High-effluent TSS | Individual particle washout | Effluent and recycle TSS or turbidity, F/M, microscopic exam, SOUR | • Pin floc – low F/M, | • Increase waste cycle, decrease MLSS. |
| | | | • Pin floc – denitrification | • Increase waste cycle, decease MLSS, increase anoxic cycle. |
| | | | • Pin floc – solids recycle | • Optimize solids handling. |
| | | | • Straggler floc – high F/M | • Decrease waste cycle, increase MLSS, increase aeration cycle. |
| | | | • Straggler floc – filamentous | • Identify filamentous organism (see filamentous control above). |
| | | | • Straggler floc – hydraulic | • See mechanical troubleshooting section. |
| | | | • Individual bacterial cells in effluent | • Decrease waste cycle, raise MLSS, increase aeration cycle, if toxicity, remove source of toxic influent. |
| **V.** High-effluent NO3 - N | High effluent NO3 – N | NO3 – N, pH, TOC or COD | • Lack of or inadequate anoxic conditions | • Increase anoxic cycle (may require decreasing oxic cycle). |
| | | | • Lack of or inadequate carbon source | • Add carbon (methanol or acetic acid). |
| | | | • Low pH, temperature or MCRT | • Add alkalinity, increase MCRT. |

| | | | | |
|---|---|---|---|---|
| **VI.** Difficulty in maintaining chlorine residual | Chlorine (Cl2)residual fluctuation,no chlorine residual | Cl2 residual, supernatant NH3-N., NO2-N, turbidity or TSS | • Incomplete nitrification/denitrification resulting in high NO2-N in supernatant. | • High NO2-N in supernatant will result in increased demand. Optimize nitrification and denitrification processes. |
| | | | • High TSS in supernatant | • High TSS in supernatant will result in increased demand. See Problems I, III, IV. |
| | | | • Reducing agents in supernatant | Reducing agents such as H2S, Fe, Mn in supernatant. Investigate source and eliminate. Increase chlorine feed rate to overcome demand |
| **VII.** High fecal coliform values | Sufficient chlorine (Cl2)residual, but highfecal coliform values | Supernatant TSS, free and total Cl2 residual,supernatant NH3-N,theoretical and actual CCC detention time | • Excessive TSS in supernatant | • High TSS in supernatant can result in "blinding" of disinfection process. See Problems I, III, IV. |
| | | | Short circuiting of chlorine contact chamber (CCC) | • Calculate the theoretical CCC detentior time. Conduct dye testing to determine actual detention time. |
| | | | • Chloro-organic compounds | • If there is no NH3-N in effluent but organic nitrogen is present, then false residual (DPD)may be present due to formation of chloro-organic compounds. Use free chlorine to establish residual not total chlorine. Reduce aeratio cycle to de-optimize nitrification rate. |
| **VIII.** Foam | Excessive foam or scum on surface of SBR, flow EQ tank or | Microbiological examination, NO3-N, C-N-P D.O. ratio, SRT, oils and grease, | • Excessive filamentous bacteria. | • The presence of hydrophobic filamentou bacteria may lead to excessive scum and foar See section I.5. |

| | | | | |
|---|---|---|---|---|
| | chlorine contact chamber | | • Denitrification | • Denitrification can result in sludge and foam on surface of SBR. |
| | | | • Nutrient deficiency | Foam may also indicate a possible nutrient deficiency. This type of foam may be due to bacteria producing a natural polymer when subjected to nutrient deficient conditions for an excessive period of time. |
| | | | • SRT | • Both too low and too high an SRT can cause foam problems. |
| | | | • Fats,oil or grease | Fats, oils grease and other non-degraded surface active organics can cause foam problems. |
| | | | • Overaeration | • Excessive (D.O. > 4.0 mg/L) may cause foaming. |