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Technical Standard for Sewerage System ≤ 10,000 PE

TS(T-P) 0102-1:2018

Technical Standard for Sewage Treatment Plant for Liquid Stream (Biological Process) - Part 1: EA & SBR

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Appendix A – Recommended Population Equivalent (PE)
Foreword
Committee Representation

This Technical Standard for Sewage Treatment Plant for Liquid Stream (Biological Process) – Part 1: EA & SBR has been prepared by a Task Force and reviewed by Technical Working Group comprising of representatives from the following Government Agencies, Scientific and Professional bodies, Consultants, Suppliers and Specialist Contractors.
1.0 Introduction

This technical standard sets out the requirements for a sewerage system to cater for a design population of 10,000 PE or less.

2.0 Scope

TS(T-P)0102-1:2018 shall cover the design, construction and special requirements for the biological treatment processes of the liquid stream within the sewage treatment plant, as follows:

(a) Extended Aeration (EA) System.
(b) Sequencing Batch Reactor (SBR) System.

3.0 Normative References

The normative references that are relevant to TS(T-P)0102-1:2018 are as follows:

(b) Environmental Quality (Sewage) Regulations 2009, EQ(S)R 2009
(c) Factories and Machinery Act 1967.
(d) Occupational Safety and Health Act 1994.
(e) Local Government Act 1976.
(f) Occupational Safety and Health Act, OSHA 514, 1994.
(g) Street, Drainage and Building Act 1974.
(h) Uniform Building By Law 1984.
(i) Akta Bekalan Elektrik 1990 (Akta 448).
(m) Tuning Biological Nutrient Removal Plants, Ken Hartley, IWA, 2013.
(q) Malaysian Standards


(r) British Standards:


(iii) BS 7079:2009 – General introduction to standards for preparation of steel substrates before application of paints and related products.


(viii) BS EN 10029:2010 – Hot-rolled steel plates 3 mm thick or above. Tolerances on dimensions and shape.


(xii) BS EN 10210-2:2006 – Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties.


(s) Australian / New Zealand Standards


4.0 Abbreviation

AMN Ammoniacal Nitrogen
BOD$_5$ Biological Oxygen Demand, 5 days at 20°C
BWL Bottom Water Level
c/c Centre to centre
CFU Colony-Forming Unit
COD Chemical Oxygen Demand
DO Dissolved Oxygen
EA Extended Aeration
E. Coli Escherichia Coli
EQ(S)R Environmental Quality (Sewage) Regulations, 2009
EWS Early Warning System
F/M Ratio Food to Microorganism Ratio
FRP Fibre Reinforced Polyester
HMI Human-Machine Interface
HRT Hydraulic Retention Time
IEC International Electrotechnical Commission
M&E Mechanical and Electrical
MLSS Mixed Liquor Suspended Solids
N/A Not Applicable
O&G Oil and Grease
### 5.0 Definition

**Activated Sludge** - refers to the flocculant microbial mass, produced when sewage is continuously aerated.

**Aerobic Action** - refers to the biological process promoted by action of bacteria in the presence of dissolved oxygen.

**Anaerobic Action** - refers to the biological process promoted by action of bacteria in the absence of dissolved oxygen.

**Baffle** - refers to the plate / structure that is installed or constructed in the process tank to promote uniform flow.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂</td>
<td>Oxygen</td>
</tr>
<tr>
<td>OSHA</td>
<td>Occupational Safety and Health Administration</td>
</tr>
<tr>
<td>PE</td>
<td>Population Equivalent</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>Qavg</td>
<td>Average Flow Rate</td>
</tr>
<tr>
<td>Qpeak</td>
<td>Peak Flow Rate</td>
</tr>
<tr>
<td>QRAS</td>
<td>Returned Activated Sludge Flow Rate</td>
</tr>
<tr>
<td>RAS</td>
<td>Returned Activated Sludge</td>
</tr>
<tr>
<td>RC</td>
<td>Reinforced Concrete</td>
</tr>
<tr>
<td>sBOD</td>
<td>Soluble Biological Oxygen Demand</td>
</tr>
<tr>
<td>SBR</td>
<td>Sequencing Batch Reactor</td>
</tr>
<tr>
<td>SOHO</td>
<td>Small Office/Home Office</td>
</tr>
<tr>
<td>SOTE</td>
<td>Standard Oxygen Transfer Efficiency</td>
</tr>
<tr>
<td>SPAN</td>
<td>Suruhanjaya Perkhidmatan Air Negara (National Water Services Commission)</td>
</tr>
<tr>
<td>SS</td>
<td>Suspended Solid</td>
</tr>
<tr>
<td>STP</td>
<td>Sewage Treatment Plant</td>
</tr>
<tr>
<td>SVI</td>
<td>Sludge Volume Index</td>
</tr>
<tr>
<td>Tfill</td>
<td>Filling Time</td>
</tr>
<tr>
<td>TN</td>
<td>Total Nitrogen</td>
</tr>
<tr>
<td>TP</td>
<td>Total Phosphorus</td>
</tr>
<tr>
<td>TWL</td>
<td>Top Water Level</td>
</tr>
<tr>
<td>UV</td>
<td>Ultraviolet</td>
</tr>
<tr>
<td>Vfill</td>
<td>Fill Volume</td>
</tr>
</tbody>
</table>
throughout the tank and to avoid short-circuiting.

**BOD$_5$** - refers to the Biological Oxygen Demand, which is the amount of dissolved oxygen consumed by the microbiological action when a sample is incubated for 5 days at 20°C.

**Bottom Water Level (BWL)** - refers to the minimum operating water level in pump well and other process tanks.

**COD** - refers to the Chemical Oxygen Demand, which is the concentration of oxygen equivalent to the amount of oxidant such as dichromate consumed when the sewage is treated with that under defined conditions.

**Competent Person** - refers to a person who is qualified to submit sewerage planning and design, supervise the construction, installation, testing and inspection of the sewerage works or septic tank works as particularly set out in the Schedule 1, Water Services Industry Act 2006 (Planning, Design and Construction of Sewerage System and Septic Tank) Rules 2013 [P.U.(A) 214].

**Drainage** - refers to the action or process of removing the liquid from any structure.

**Effluent** - refers to the treated fluid discharged from the sewage treatment plant.

**Equipment** - refers to any component which is installed in, mounted on, attached to, or operated on structures in the performance of their intended function.

**Extension** - refers to the additional structure or system that connected to the existing structure or system that is provided with similar the access.

**Freeboard** - refers to the space between top water level and the top of the channel or process tank.

**Grease** - refers to the thick oily and floating substance that is typically generated from kitchen waste.

**Grit** - refers to the small loose particles of stone or sand found in the sewage.

**Instrumentation** - refers to the device for measuring the operation and performance of various processes and controls.

**Mixed Liquor** - refers to the mixer of sewage and activated sludge undergoing circulation and aeration in the aeration tank or
Mixed Liquor Suspended Solid (MLSS) - refers to the concentration of dry solids in mg/l of mixed liquor in the aeration tank or channel of an activated sludge plant.

Odour - refers to Organoleptic attribute perceptible by the olfactory organ on sniffing certain volatile substances.

Parameter - refers to any of the factors listed in the Third and Fifth Schedules in the Environment Quality (Sewage) Regulations, 2009.

Performance Requirements - refers to the functions that a system has to perform in order to operate as required.

Population Equivalent (PE) - refers to the population equivalent in terms of fixed population of a varying or transient population for domestic wastes from sectors which include residential, commercial and industrial that contribute flow to the sewerage system.

Range - refers to the group of products within which the selected property(s) is /are similar for all products within that group.

Retention Time - refers to the average length of time the sewage is retained within the given process unit within in the sewerage system. It is also known as Residence Time.

Sample - refers to the representative part or a single item from a larger whole or group, which shall be selected at random without regard to quality, especially when presented for inspection or shown as evidence of quality, style, or nature of the whole.

Sewage - refers to any liquid discharges containing human excreta, animal or vegetable matters in suspensions or solution derived from domestic activities and being generated from the household, commercial, institutional and industrial premises including liquid discharges from water closets, basins, sinks, bathrooms and other sanitary appliances but excluding rain water and prohibited effluent.

Sewage Sludge - refers to the residual mixture of solid and liquid produced during the partial or full treatment of sewage but does not include treated sewage effluent discharged through a disposal pipe.

Sewerage System - refers to a system incorporating sewers, disposal pipes,
pumping stations or sewage treatment works or any combination thereof and all other structures, equipment and appurtenances (other than individual internal sewerage piping, common internal sewerage piping or septic tanks) used or intended to be used for the collection, conveyance, pumping or treatment of sewage and sewage sludge or the disposal of treated sewage effluent or sewage sludge.

Suspended Solid (SS) - refers to the solid in suspension in sewage liquor.

Top Water Level (TWL) - refers to the maximum water level in a channel, process tank, an aeration tank, oxidation ditch or a sludge storage tank or any other sewage treatment structure.

Unit Process - refers to any structure including any related equipment which is used as a process stage and which can be isolated from other parallel, upstream or downstream structures.

6.0 Design Criteria

(a) All sewage treatment plants (STP) shall be designed to meet Environmental Quality (Sewage) Regulations, EQ(S)R, 2009 Standard A or Standard B requirements including, nitrification and denitrification to reduce ammonia and total nitrogen level, as set out in Table 3.1. Total phosphorus removal must also be considered for STP where treated effluent is to be discharged into stagnant water bodies.

(b) Effluent discharge to recreational and tourist beaches shall comply to Standard A to meet EQ(S)R 2009. E. Coli shall not exceed 300 CFU/100 ml.

(c) The STP shall comply with the following conditions:

(i) Ensure the treatment process is capable of handling sewage characteristics, as set out in Table 3.2.

(ii) Sufficient land area is available for the STP plus additional area to allow for future extensions to the plant (if any anticipated), internal road and parking, drainage, flood mitigation and landscape.

(iii) Ensure that odour and noise are controlled and mitigated through proper design, followed by effective operations and maintenance.

(d) The population equivalent (PE) for various premises or establishment is indicated in Appendix A.

(e) Mass balance and process kinetic calculation shall be computed for all biological treatment system proposed for the STP.

(f) Short circuiting shall be avoided in all unit processes.
(g) Dedicated mixing equipment shall be provided where nutrient removal is required.

Diffused air mixing is not permitted.

Table 3.1: Design Values for Effluent Quality based on EQ(S)R

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Effluent Discharge to Rivers / Stream (mg/l)</th>
<th>Effluent Discharge to Stagnant Water Bodies (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD₅</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>SS</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>COD</td>
<td>120</td>
<td>60</td>
</tr>
<tr>
<td>Ammoniacal Nitrogen</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Nitrate Nitrogen</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>O&amp;G</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

(Ref: Schedule 2, EQ(S)R, 2009)

Table 3.2: Design Values for Raw Sewage Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biochemical Oxygen Demand (BOD₅)</td>
<td>56</td>
</tr>
<tr>
<td>Suspended Solids (SS)</td>
<td>68</td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>113</td>
</tr>
<tr>
<td>Total Nitrogen (TN)</td>
<td>11</td>
</tr>
<tr>
<td>Ammoniacal nitrogen (AMN)</td>
<td>7</td>
</tr>
<tr>
<td>Total Phosphorus (TP)</td>
<td>2</td>
</tr>
<tr>
<td>Oil and Grease (O&amp;G)</td>
<td>11</td>
</tr>
</tbody>
</table>
7.0 Extended Aeration (EA) System

7.1 General

(a) Extended Aeration (EA) process utilises activated mass of aerobic micro-organisms in the wastewater (commonly referred to as activated sludge) to consume the organics (both the soluble and settleable) in the presence of dissolved oxygen.

(b) The EA process comprises of the anoxic compartment followed by the aeration tank and the clarifier. Part of the activated sludge from the clarifier is returned to the aeration tank to maintain the mixed liquor suspended solids (MLSS). Refer to Figure 3.1 which illustrates the typical process flow pattern through the EA.

(c) The EA plant shall be designed to receive either plug or completely mixed flow of pre-treated sewage from the grit and grease chamber. The sewage shall be divided and channelled into the anoxic compartment and thereafter into the aeration tank.

(d) The biological tank of EA plant shall not exceed 1.2 m above ground.

Figure 3.1: Schematic Diagram for EA System

7.2 Design Requirements for Anoxic Compartment

(a) The anoxic compartment shall be a RC open tank, as set out in Table 3.3.

(b) There shall be adequate mixing within the anoxic compartment without any dissolved oxygen. A submersible electric mixer shall be provided to ensure the solids and biomasses in the anoxic compartment are maintained fully suspended.
(c) A portion of the MLSS from the aeration tank shall be recycled to the anoxic compartment, to ensure proper nutrient removal.

(d) Return Activated Sludge (RAS) from clarifier shall be recycled to the aeration tank, to ensure that the MLSS is maintained to the required level.

Table 3.3: Design Requirements for Anoxic Compartment

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type of anoxic compartment</td>
<td>RC open tank</td>
</tr>
<tr>
<td>2.</td>
<td>Number of Anoxic Compartments</td>
<td>Minimum 2 units in parallel for PE &gt; 1,000.</td>
</tr>
<tr>
<td>3.</td>
<td>Hydraulic retention time (HRT)</td>
<td>2 – 4 hours at Q_{avg}</td>
</tr>
<tr>
<td>4.</td>
<td>MLSS required</td>
<td>2,000 – 4,000 mg/l</td>
</tr>
<tr>
<td>5.</td>
<td>MLSS recycle ratio</td>
<td>2 – 4 times at Q_{avg}</td>
</tr>
<tr>
<td>6.</td>
<td>Outlet position</td>
<td>Top overflow to aeration tank</td>
</tr>
<tr>
<td>7.</td>
<td>Minimum width of anoxic compartment</td>
<td>1.2 m</td>
</tr>
<tr>
<td>8.</td>
<td>DO concentration</td>
<td>&lt; 0.5 mg/l</td>
</tr>
</tbody>
</table>

7.3 Design Requirements for Aeration Tank

(a) The design requirements for the aeration tank shall be in accordance with Table 3.4.

(b) A baffle with 1/3 of water level opening from aeration tank floor level is required in the Aeration Tank for PE \leq 1,000 to minimize short-circuiting.

(c) Mixing design must avoid both insufficient and excessive mixing situation.

(d) Standby unit shall be equivalent capacity of the duty unit.

Table 3.4: Design Parameters for Aeration Tank

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Number of aeration tanks</td>
<td>Minimum 2 tanks in parallel, with provision to isolate either one tank for maintenance</td>
</tr>
<tr>
<td>2.</td>
<td>Tank dimension</td>
<td>Length : Width Ratio is 2.5 : 1&lt;br&gt;Water Depth:&lt;br&gt;• PE \leq 1,000: 3m&lt;br&gt;• PE &gt; 1,000: 3 – 4 m</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td>Requirement</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>3.</td>
<td>Freeboard</td>
<td>Minimum 500 mm</td>
</tr>
<tr>
<td>4.</td>
<td>Hydraulic retention time (HRT)</td>
<td>18 – 24 hours at $Q_{\text{avg}}$</td>
</tr>
<tr>
<td>5.</td>
<td>Mixed liquor suspended solids (MLSS)</td>
<td>2,000 – 4,000 mg/l</td>
</tr>
<tr>
<td>6.</td>
<td>F/M Ratio</td>
<td>0.05 – 0.1 day$^1$</td>
</tr>
<tr>
<td>7.</td>
<td>Oxygen requirement for BOD$_5$ and ammoniacal nitrogen removal</td>
<td>Minimum 2 kg O$_2$/ kg Substrate Removed</td>
</tr>
<tr>
<td>8.</td>
<td>Dissolved oxygen in tank</td>
<td>Minimum 2 mg/l</td>
</tr>
<tr>
<td>9.</td>
<td>Temperature</td>
<td>Maximum 28°C</td>
</tr>
<tr>
<td>10.</td>
<td>Organic loading</td>
<td>0.1 – 0.4 kg BOD$_5$/ m$^3$ day</td>
</tr>
<tr>
<td>11.</td>
<td>Correction factors:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• $\alpha$, Alpha factor for oxygen transfer coefficient</td>
<td>0.4 to 0.8 for diffused air system</td>
</tr>
<tr>
<td></td>
<td>• $\beta$, Beta factor for oxygen saturation concentration</td>
<td>0.7 - 0.98</td>
</tr>
<tr>
<td>12.</td>
<td>Sludge age</td>
<td>&gt; 20 days</td>
</tr>
<tr>
<td>13.</td>
<td>Recirculation ratio, $Q_{\text{RAS}}/Q_{\text{avg}}$ (returned to the head of aeration tank)</td>
<td>0.5 – 1.5</td>
</tr>
<tr>
<td>14.</td>
<td>SVI</td>
<td>100 – 150 ml/g</td>
</tr>
<tr>
<td>15.</td>
<td>Minimum mixing requirement</td>
<td>0.04 m$^3$/ m$^2$. min</td>
</tr>
<tr>
<td>16.</td>
<td>MLSS pump per tank</td>
<td>1 duty, 1 standby</td>
</tr>
</tbody>
</table>
8.0 Sequencing Batch Reactors (SBR) System

(a) The SBR is an activated sludge process that functions as biological reactor and clarifier in predetermined sequences. The arrangement of the processes in the SBR system is as follows:

```
| Fill | React* (Anoxic, Aeration) | Settle | Decant | Idle (Optional) |
```

Note:
* To incorporate anaerobic phase (biological phosphorus removal) where applicable.

(b) Idle phase is included as an optional item for SBR system and the cycle time may vary based on the system requirement.

(c) Intermittently fill and intermittently decant SBR system consists of a minimum of two (2) reactors in parallel. When one unit of the reactors is in fill mode, the other reactor(s) may be in the stage of react, settle, decant or idle. The configuration of the biological process can be with or without equalization tank/selector ahead the reactors, and anoxic phase with submersible mixer must be incorporated in the reactors to ensure proper mixing. MLSS recycle is applicable for SBR with selector design. Refer to Figure 3.3 for the typical layout of the intermittently fill and intermittently decant SBR treatment process.

(d) Continuous fill and intermittently decant system is one of the variations of this system, where feeding into all reactors are continuous but the other phases (react, settle, decant, idle) shall run in sequence. Anoxic phase with submersible mixer shall be incorporated in the intermittently decant compartment to ensure proper mixing. The design has to ensure continuous inflow of wastewater not causing disturbance during all phases of the cycle, i.e. settling and decanting phase, and produce high quality
effluent. Refer to Figure 3.4 for the typical layout of the continuous fill and intermittently decant SBR treatment process.

(e) In the reaction stage, oxygen shall be supplied to the system in accordance with the load. This generally requires higher oxygen capacity per unit time compared to a continuously aerate system.

(f) In the decant stage, there shall be sufficient time to allow for MLSS to settle before effluent decanting begins. Treated effluent should be drawn from decanter. Decanting time is normally shorter than fill time. Consequently, the effluent flow rate will also be higher than influent flow rate.

(g) The design of the decanting weir shall be capable of handling high over-flow rate without scouring the settled sludge. The depth of water decanted shall be restricted to prevent scouring of solids.

(h) Sufficient clear water depth shall be allowed in between the minimum water level after decanting and the top of the settled sludge blanket, to minimize sludge carry over.

(i) Denitrification in the SBR process is achieved when a distinguish mixing phase or anoxic treatment time to be allocated within the cycle time to allow for denitrification to occur.

(j) The time for the anoxic, aerobic and anaerobic condition, shall be calculated and applied accordingly.

(k) Programmable Logic Controller (PLC) shall be provided for automatic operation of SBR system.

(l) Allowance shall be provided to completely empty a tank for maintenance purposes without interrupting the operating sequence of the plant.

(m) The biological tank of SBR plant shall not exceed 2.5 m above ground.

(n) Standby unit shall be equivalent capacity of the duty unit.

(o) SBR shall be designed based on the parameters provided in Table 3.5.

**Table 3.5: Design Parameters for SBR System**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Continuous Fill and Intermittently Decant</th>
<th>Intermittently Fill and Intermittently Decant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Number of reactor</td>
<td>Minimum 2 units</td>
<td>Minimum 2 units</td>
</tr>
<tr>
<td>2.</td>
<td>Water depth</td>
<td>3 to 5 m</td>
<td>3 to 5 m</td>
</tr>
<tr>
<td>3.</td>
<td>Freeboard</td>
<td>Minimum 500 mm</td>
<td>Minimum 500 mm</td>
</tr>
<tr>
<td>4.</td>
<td>F/M ratio</td>
<td>0.05 – 0.1 day(^{-1})</td>
<td>0.05 – 0.1 day(^{-1})</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td>Continuous Fill and Intermittently Decant</td>
<td>Intermittently Fill and Intermittently Decant</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>5.</td>
<td>Hydraulic retention time at $Q_{avg}$ (at mid decant depth)</td>
<td>18 – 24 hours</td>
<td>18 – 24 hours</td>
</tr>
<tr>
<td>6.</td>
<td>Sludge age</td>
<td>15 – 30 days</td>
<td>15 – 30 days</td>
</tr>
<tr>
<td>7.</td>
<td>Sludge yield</td>
<td>0.4 – 0.6 kg sludge / kg BOD$_5$ removed</td>
<td>0.4 – 0.6 kg sludge / kg BOD$_5$ removed</td>
</tr>
<tr>
<td>8.</td>
<td>SVI</td>
<td>100 – 150 ml / g</td>
<td>100 – 150 ml / g</td>
</tr>
<tr>
<td>9.</td>
<td>MLSS (End of decant)</td>
<td>2,500 – 4,500 mg / l</td>
<td>2,500 – 4,500 mg / l</td>
</tr>
<tr>
<td>10.</td>
<td>Cycle time per reactor</td>
<td>4 – 8 hours / reactor</td>
<td>4 – 8 hours / reactor</td>
</tr>
<tr>
<td>11.</td>
<td>Fill volume per cycle</td>
<td>$V_{fill} = \left( Q_{peak} \text{ m}^3/\text{hr} \times 1.5\text{hr} \right) + \left( T_{fill} - 1.5 \right) \times Q_{avg} \text{ m}^3$ (if no equalization tank)</td>
<td>$V_{fill} = \left( Q_{peak} \text{ m}^3/\text{hr} \times 1.5\text{hr} \right) + \left( T_{fill} - 1.5 \right) \times Q_{avg} \text{ m}^3$ (Applicable for single reactor if no equalization tank)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{fill} = Q_{avg} \times T_{fill} \text{ m}^3$ (if preceded by continuously aerated compartment)</td>
<td>$V_{fill} = Q_{avg} \times T_{fill} \text{ m}^3$ (if preceded by equalization tank)</td>
</tr>
<tr>
<td>12.</td>
<td>Dissolved oxygen (reactor)</td>
<td>0 – 6.5 mg/l</td>
<td>0 – 6.5 mg/l</td>
</tr>
<tr>
<td>13.</td>
<td>Oxygen requirement for BOD$_5$ and ammoniacal nitrogen removal</td>
<td>[2.0 kg O$_2$ / kg substrate removed] x [Cycle time / aeration time]</td>
<td>[2.0 kg O$_2$ / kg substrate removed] x [Cycle time / aeration time]</td>
</tr>
<tr>
<td>14.</td>
<td>Correction factor for:</td>
<td>0.4 to 0.8 for diffused air system</td>
<td>0.4 to 0.8 for diffused air system</td>
</tr>
<tr>
<td></td>
<td>• $\alpha$, Alpha factor for oxygen transfer coefficient</td>
<td>0.7 - 0.98</td>
<td>0.7 - 0.98</td>
</tr>
<tr>
<td></td>
<td>• $\beta$, Beta factor for oxygen saturation concentration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Decant time</td>
<td>$\geq 1.0$ hour</td>
<td>$\geq 1.0$ hour</td>
</tr>
<tr>
<td>16.</td>
<td>Decant depth</td>
<td>$\leq 25%$ from TWL</td>
<td>$\leq 30%$ from TWL</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td>Continuous Fill and Intermittently Decant</td>
<td>Intermittently Fill and Intermittently Decant</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>--------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>17.</td>
<td>Decant volume</td>
<td>≤ 25% of Volume of biological reactor at TWL</td>
<td>≤ 30% of Volume of biological reactor at TWL</td>
</tr>
<tr>
<td>18.</td>
<td>Clear water depth from BWL to top of sludge blanket</td>
<td>≥ 1.0 m</td>
<td>≥ 1.0 m</td>
</tr>
<tr>
<td>19.</td>
<td>Decanting device loading rate</td>
<td>Maximum 90 m³/m/hr for decant draw-down from TWL (moving arm) ≤ 20 m³/m/hr for decant draw-down at BWL (siphon decanter)</td>
<td>Maximum 90 m³/m/hr for decant draw-down from TWL (moving arm) ≤ 20 m³/m/hr for decant draw-down at BWL (siphon decanter)</td>
</tr>
<tr>
<td>20.</td>
<td>Maximum decanter length</td>
<td>4 m (moving arm) 8 m (siphon decanter)</td>
<td>4 m (moving arm) 8 m (siphon decanter)</td>
</tr>
<tr>
<td>21.</td>
<td>Minimum number of decanter per tank</td>
<td>2 units moving arm decanters per tank (each with individual drive) 1 unit siphon decanter per tank (with cold standby motorized valve)</td>
<td>2 units moving arm decanters per tank (each with individual drive) 1 unit siphon decanter per tank (with cold standby motorized valve)</td>
</tr>
<tr>
<td>22.</td>
<td>MLSS recirculation</td>
<td>≥ 2 x Q_{avg}</td>
<td>0.1 – 0.3 x Q_{avg}</td>
</tr>
<tr>
<td>23.</td>
<td>Rising rate at Q_{peak}</td>
<td>≤ 1 m/hr</td>
<td>N/A</td>
</tr>
<tr>
<td>24.</td>
<td>Horizontal flow velocity during decant*</td>
<td>≤ 0.03 m/s</td>
<td>≤ 0.03 m/s</td>
</tr>
<tr>
<td>25.</td>
<td>Settling time</td>
<td>Minimum 50 min</td>
<td>Minimum 50 min</td>
</tr>
<tr>
<td>26.</td>
<td>MLSS pump per tank</td>
<td>1 duty, 1 standby</td>
<td>1 duty, 1 standby</td>
</tr>
</tbody>
</table>

Notes:

* Horizontal flow velocity is defined as decant flowrate divided the cross-sectional area between top water level and top of the sludge blanket.
Figure 3.3: Schematic Flow Diagram for Intermittently Fill Intermittently Decant SBR Process

Figure 3.4: Schematic Flow Diagram for Continuous Fill and Intermittently Decant SBR Treatment Process
9.0 Biological Phosphorus Removal

(a) Total phosphorus removal must be considered for STP where treated effluent is to be discharged into stagnant water bodies.

(b) The removal of phosphorus shall be achieved by incorporating MLSS recycle to the anaerobic compartment, which is prior to the anoxic compartment.

(c) The hydraulic retention time shall be between 0.5 and 1.5 hours. The adequacy of the phosphorus removal shall be verified and supported with process kinetic and mass balance calculations including the availability and uptake of soluble BOD (sBOD).

10.0 Design Requirements for Biological Process Equipment

10.1 General

(a) The biological processes shall be provided with mechanical and electrical (M&E) fixtures such as air blowers, MLSS pumps, other pumps, mixers, power supply, cabling, lighting, control panels, programmable logic controllers (PLC) where applicable etc.

(b) The M&E fixtures shall be installed in multiple units to facilitate operational flexibility of the plant.

(c) For SBR process, the mixing equipment shall be sized to ensure thorough mixing through the entire basin from a settled condition within 5 minutes without entrainment of air into the content. Also, the downstream facilities shall be sized to handle peak decanting flow rate that will occur during decant phase.

10.2 Mixers

(a) Submersible mixers shall be provided in the anoxic compartments or during anoxic periods/phase and anaerobic compartments, to ensure proper mixing and to maintain the optimum conditions for nutrient removal without inducing dissolved oxygen.

(b) Standby unit shall be equivalent capacity of the duty unit.

(c) Mixers with adequate mixing thrust shall be suitably located and positioned to ensure proper mixing and no dead zone.

(d) The design requirements for the mixer shall be in accordance with Table 3.6.

Table 3.6: Design Requirements for Mixers

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mixing Power</td>
<td>Minimum 5 W / m³</td>
</tr>
<tr>
<td>2.</td>
<td>Number of Mixer per tank</td>
<td>PE ≤ 500 – 1 unit; PE &gt; 500 – Minimum 1 duty, 1 standby</td>
</tr>
</tbody>
</table>
10.3 Aeration System

(a) The aeration system shall provide adequate oxygen to the sewage to promote aerobic microorganisms for the process of biodegradation of the organics. In this case, the acceptable method of aerating sewage is by using diffused air.

(b) The other requirements of the aeration system are provided in TS(CT)03-1:2018, Section 7.13 on pumps requirements.

(c) The aeration system using diffusers shall comprise of air blowers, pipe works and fittings, as indicated in Table 3.7. The diffusers shall be fine-bubble type. In using the fine-bubble diffusers, the competent person shall ensure proper mixing is achievable.

(d) The diffuser system shall be designed and installed as follows:
   (i) Air supply to the aeration tank shall be provided with a dedicated air blower.
   (ii) A minimum concentration of DO must be maintained in the mixed liquor as required for the process selected. Refer Table 3.4, item 8 and Table 3.5, item 12 for the respective DO requirement for EA and SBR system.
   (iii) The air rate per square meter of diffuser horizontal surface shall be based on the mid-range of the maximum rated diffuser capacity.
   (iv) Air supply must be evenly distributed in the reactor with no dead zones or sludge deposition, to maintain the biomass in suspension.
   (v) Maximum distance between the air diffuser to air diffuser as well as air diffuser to wall shall not exceed 1.2 m c/c for disc diffuser or 1.2 m end to end for tube diffuser.
   (vi) The length of the lateral diffuser pipes shall not exceed the width of the tank.
   (vii) DO demand shall always be met in any circumstances to ensure proper process performance, i.e. any blower out of service.
   (viii) Ensure proper noise control from the diffused aeration system. Refer TS(CT) 03-1:2018, page 12 on noise control requirements.
   (ix) Standard Oxygen Transfer Efficiency (SOTE) in clear water, which shall be based on selected manufacturer declared SOTE at the specific design water depth. The SOTE shall be at least 22% in clean water at 20°C, at a depth not exceeding 5 m and an air flow rate per diffuser not less than that determined at the peak air requirement.
   (x) Arrange the diffusers in proper grid complete with purge line to ensure proper mixing and uniform pressure loss.
   (xi) Provide adequate discharge points to purge the moisture trapped in the air distribution pipes.
   (xii) Diffusers must be placed maximum 0.3 m from tank floor.
(xiii) Ensure the actual air flow rates from the compressed air system comply with the design flow rate. The system shall have the ability to vary air flow rates.

(xiv) Automatic variation of air flow rates shall be provided for STP > 5,000 PE.

(xv) DO probes shall be appropriately located within the aeration tank. The alarm shall be set to trigger when DO falls to 1 mg/L or less.

(xvi) The total head loss from blower outlet (or silencer outlet, where used) to the diffuser inlet shall not exceed 3.4kPa (0.5 psi) at average operating conditions.

(xvii) Air valves shall be provided for each grid of the diffuser system.

(xviii) Standby unit shall be equivalent capacity of the duty unit.

Table 3.7: Requirements of the Air Blowers and Diffusers

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Air blower for the compressed air system</td>
<td>PE ≤ 2,000: Minimum 1 duty and 1 standby PE &gt; 2,000: Minimum 2 duty and 1 standby</td>
</tr>
<tr>
<td>2.</td>
<td>Type of air diffuser</td>
<td>Fine bubble disc or tube type</td>
</tr>
</tbody>
</table>

10.4 Pumps

(a) Appropriate pumps shall be provided for the following functions:

(i) For pumping the MLSS from aeration tank to anoxic compartment.

(ii) For pumping the liquid from aeration tank to clarifier (where required).

(iii) For pumping recycle activated sludge (RAS) from clarifier to aeration tank to maintain the MLSS as required.

(b) The other requirements of the pumps are provided in TS(CT)03-1:2018, page 15 on pumps requirements.

10.5 DO Instrumentation

(a) Instrumentation is required for STP > 5,000 PE. This is to allow the optimisation of the biological process.

(b) Minimum equipment required is fixed DO meter.

(i) Minimum one (1) DO of optical dissolved oxygen sensor type per tank shall be appropriately installed within the biological tank.

(ii) DO meter shall be complete with recorder.

(iii) The DO reading shall be connected to the PLC controlling aeration equipment.

(iv) Sufficient accessibility shall be provided for maintenance purposes.
10.6 Control System

10.6.1 Programmable Logic Controllers (PLC)

(a) The biological processes shall be provided with proper PLC to ensure rapid process recovery or minimise the deterioration of effluent quality.

(b) PLC shall be provided for the following plant:

(i) EA > 5,000 PE

(ii) All SBR

(c) Refer TS(CT)03-1:2018, page 37 for the requirements of PLC.

10.6.2 Early Warning System (EWS)

STP shall be provided with EWS. Refer TS(CT)03-1:2018, page 51 for the requirements of EWS.

11.0 Enclosed STP

(a) Where the STP is in urban areas without adequate buffer zone, the inlet works, biological process units and sludge handling facilities shall be properly covered.

(b) No unit processes shall be located outside the enclosed buildings/architectural enclosures.

(c) Special consideration shall be given for the following:

(i) Odour control. Refer to TS(CT)04-1:2018, page 10.

(ii) Ventilation. Refer to TS(CT)03-1:2018, page 12.

(iii) Noise control. Refer to TS(CT)03-1:2018, page 12.

(iv) Fire safety to comply with Uniform Building By Law 1984.

(v) Electrical requirements. Refer to TS(CT)03-1:2018.

(vi) Operation and maintenance requirement.

(vii) Appropriate architecture and landscape, to camouflage the STP and blend with the surrounding properties.

(viii) Proper vehicle access for removal of the screenings collected and sludge from the STP as well as for maintenance and repair purposes.

(ix) The STP being in confined space, shall be provided with safety measures in compliance with relevant occupational health and safety regulations. Such areas shall be provided with proper warning notices.

(d) The covering provided to inlet works, biological process units and sludge handling facilities shall be able to withstand the weather conditions, and as follows:

(i) Plastic or fiberglass cover if used, shall be manufactured with UV inhibitor and will not warp or deform due to weathering effect. Where chipping
might occur at the edge of the cover, stainless steel reinforcement frame on all sides of a plastic or FRP cover shall be provided. The covers shall be provided with anodised aluminium frame, which shall be securely fastened to the concrete structures.

(ii) Corrugated metal covers if used, must have appropriate corrosion resistant coating.

(iii) The covers shall be designed to allow for easy dismantling and easy access for cleaning of the enclosed plant.

(iv) Alternatively, brickwall complete with supporting RC columns, beams and footing can be used to cover the STP.

(e) Bins used for the storage of screenings and grit collected in the pre-treatment area shall be completely covered to reduce visual impact, odour and to keep vectors away. The designer shall provide further considerations on the size, type and method of emptying the bins.

12.0 Mechanical and Electrical Requirements

Refer to TS(CT) 03-1:2018 for mechanical and electrical requirements.

13.0 Other Amenities

Refer to TS(CT) 04-1:2018 for the requirements on other amenities.

14.0 Construction Requirements

14.1 General

All construction method shall comply with the relevant Occupational Safety and Health Act (OSHA) requirements for safety.

14.2 Reinforced Concrete Structures

(a) The design of various reinforced concrete structures shall be designed by competent person.

(b) Concrete structures shall be designed in accordance with MS 1195:1991, except that concrete structures for retaining sewage and other aqueous liquids shall be designed in accordance with BS EN 1992-3:2006. Unless otherwise stated elsewhere, the design working life of all concrete structures shall be 50 years.

(c) The foundation for all concrete structures in the STP shall be designed to withstand uneven settlement when the structures are loaded as well as buoyancy due to high water table.

(d) Concrete for structures retaining sewage shall have a strength grade not less than grade C35A. Strength grades higher than C35A may be required as design by the competent person.

(e) Concrete for purposes other than structures retaining sewage shall have a strength
grade not less than grade C20 where unreinforced, and not less than grade C30 where reinforced.


(g) Cement used shall be resistant to sulphate attack.

14.3 Structural Steel

(a) Structural steel sections shall comply with BS EN 10365:2017 or otherwise with:

(i) BS EN 10162:2003 for cold rolled steel sections.

(ii) BS EN 10210:2006 for hot rolled steel sections.

(iii) BS EN 10025:2004 for weldable structural steel.

(iv) BS EN 10296-1:2003, BS EN 10297-1:2003 and BS EN 10305:2016 for steel tube.

(b) The use of structural steel in building shall be in accordance with MS 415: PART 1: 1976.

(c) Steelwork that may be in contact with sewage through immersion, splash or spray, or that is over tanks containing sewage, shall be protected against corrosion using one of the following coating systems:

(i) high build tar epoxy system, complying with AS/NZS 3750.2:2008 and applied in two or more coats to give a total dry film thickness of not less than 200 µm.

(ii) high build micaceous iron oxide pigmented epoxy system complying with AS/NZS 3750.12:1996(R2013) and applied in two or more coats to give a total dry film thickness of not less 200 µm.

(iii) hot-dipped galvanised coating of 140 µm nominal thickness in accordance with MS 740:1981.

(iv) sealed sprayed zinc coating of 150 µm nominal thickness in accordance with BS EN ISO 2063:2017.

(d) Steelwork that is exposed to the external atmosphere, except severe marine atmospheres, shall be protected against corrosion using one of the following coating systems:

(i) a prime coat of a two packs polyamide cured epoxy zinc phosphate of dry film thickness 60 to 80 µm with a finishing coat of a high build micaceous iron oxide chlorinated rubber paint, spray applied to a dry film thickness of 60 to no more than 80 µm.

(ii) hot-dipped galvanised coating of 85 µm nominal thickness, in accordance with MS 740:1981.

(iii) sealed sprayed zinc coating of 150 µm nominal thickness, in accordance with BS EN ISO 2063:2017.
(e) Steel substrates shall be prepared before application of coatings, in accordance with BS 7079:2009.

(f) Other corrosion protection coating systems for steelwork shall be determined using BS 5493:1977 or AS/NZS 2312:2014 for tropical atmospheres, to provide 20 or more years with low maintenance.

(g) Unprotected steelwork in contact with sewage shall be stainless steel grade 316S31 complying with BS EN 10088: Part 1 and 3:2014 or BS EN 10029:2010 and BS EN ISO 9445:2010.

(h) Successive coatings of the one component shall be tinted a different colour to facilitate overcoating and inspection.

(i) Bolts, nuts, screws and other fasteners shall have either:
   (i) Hot-dipped galvanised, in accordance with MS 739:1981.
   (ii) Sherardized zinc coating, in accordance with BS EN ISO 14713-3:2017.
   (iii) Electro plating.

(j) Washers and other small components shall have either:
   (i) Hot-dipped galvanised, in accordance with MS 740:1981.
   (ii) Sherardized zinc coating, in accordance with BS EN ISO 14713-3:2017.


(l) Fasteners of incompatible material to the component being fastened shall have suitable isolating washers and sleeves.

15.0 Health and Safety Requirements

The following shall be considered throughout the design, construction and installation:

(a) Provide safe ingress and egress.

(b) Provide safe working conditions for workers and operators.

(c) Protect the adjoining properties and the public.

(d) Compliance to Occupational Safety and Health Act 1994 and Factories and Machinery Act 1967 requirements.

(e) All Electrical works shall comply to Akta Bekalan Elektrik 1990 (Akta 448), Peraturan-Peraturan Elektrik 1994 and the relevant IEC Standards.

(f) The following shall be provided:
   (i) All moving parts shall be protected by suitable guards. Where inspection is required, an open mesh with frame and suitably supported maybe used. The maximum aperture of the mesh shall be 6 mm.
(ii) All guards shall be readily removable and replaceable to the correct orientation only. However the guard shall be designed with features to prevent accidental dislocation from its’ original position. The fasteners when dropped during dismantling, must be easily retrievable and should not damage any equipment or endanger personnel, else fixed fasteners shall be used.

(iii) An emergency stop button, preferably of mushroom head type shall be located adjacent to all equipment. More than one emergency stop button shall be used, if access around the item is restricted.

(iv) Long items, such as conveyor belts, shall have an emergency lanyard applied to each accessible length of conveyor.

(v) Permanent warning signs shall be posted at visible location, dangerous areas and shall clearly indicate the nature of risk at that area. This includes warning signage at low voltage room and other hazardous areas / confined space.

16.0 Appendices

- Appendix A – Recommended Population Equivalent (PE)
### Appendix A Recommended Population Equivalent (PE)

<table>
<thead>
<tr>
<th>Type of Premises/ Establishment</th>
<th>Recommended PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>5 PE per house</td>
</tr>
<tr>
<td>Small Office/Home Office (SOHO):</td>
<td></td>
</tr>
<tr>
<td>• Gross area ≤ 450 ft²</td>
<td>2 PE per SOHO</td>
</tr>
<tr>
<td>• 450 ft² &lt; Gross area &lt; 650 ft²</td>
<td>3 PE per SOHO</td>
</tr>
<tr>
<td>• 650 ft² ≤ Gross area &lt; 700 ft²</td>
<td>4 PE per SOHO</td>
</tr>
<tr>
<td>• Gross area ≥ 700 ft²</td>
<td>5 PE per SOHO</td>
</tr>
<tr>
<td>Commercial:</td>
<td></td>
</tr>
<tr>
<td>Includes offices, shopping complex, entertainment/ recreational centres, restaurants, cafeteria, theatres</td>
<td>3 PE per 100 m² gross area</td>
</tr>
<tr>
<td>Schools/ Educational Institutions:</td>
<td></td>
</tr>
<tr>
<td>• Day schools/ Institutions</td>
<td>0.2 PE per student</td>
</tr>
<tr>
<td>• Fully residential</td>
<td>1 PE per student</td>
</tr>
<tr>
<td>• Partial residential</td>
<td>0.2 PE per non-residential student and 1 PE per residential student</td>
</tr>
<tr>
<td>Hospitals</td>
<td>4 PE per bed</td>
</tr>
<tr>
<td>Hotels with dining and laundry facilities</td>
<td>4 PE per room</td>
</tr>
<tr>
<td>Factories, excluding process water</td>
<td>0.3 PE per staff</td>
</tr>
<tr>
<td>Market (wet type)</td>
<td>3 PE per stall</td>
</tr>
<tr>
<td>Market (dry type)</td>
<td>1 PE per stall</td>
</tr>
<tr>
<td>Petrol kiosks/Service stations</td>
<td>15 PE per toilet</td>
</tr>
<tr>
<td>Bus terminal</td>
<td>4 PE per bus bay</td>
</tr>
<tr>
<td>Taxi terminal</td>
<td>4 PE per taxi bay</td>
</tr>
<tr>
<td>Mosque/ Church/ Temple</td>
<td>0.2 PE per person</td>
</tr>
<tr>
<td>Stadium</td>
<td>0.2 PE per person</td>
</tr>
<tr>
<td>Swimming pool/ Sports complex</td>
<td>0.5 PE per person</td>
</tr>
<tr>
<td>Public toilet</td>
<td>15 PE per toilet</td>
</tr>
<tr>
<td>Type of Premises/ Establishment</td>
<td>Recommended PE</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Airport</td>
<td>0.2 PE per passenger</td>
</tr>
<tr>
<td></td>
<td>0.3 PE per employee</td>
</tr>
<tr>
<td>Laundry</td>
<td>10 PE per machine</td>
</tr>
<tr>
<td>Prison</td>
<td>1 PE per person</td>
</tr>
<tr>
<td>Golf course</td>
<td>20 PE per hole</td>
</tr>
</tbody>
</table>
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