Operations and Maintenance of SBR

& Management of STP O&M

Recommended Design Parameters

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Parameter	Unit	Continuous Fill and Intermittently Decant	Intermittently Fill and Intermittently Decant
No. of Reactors	Unit	Minimum 2	Minimum 2
Hydraulic retention time at Qavg (at average water level	hr	18 – 24	18 – 24
F/M Ratio	d^{-1}	0.05 – 0.08	0.05 – 0.30
Sludge Age	D	20 – 30	10 – 30
Sludge Yield	kg sludge/ kg Load	0.75	0.75
MLSS (End of Decant)	mg/L	3,000 – 4,500	3,000 – 5,000
Cycle Time	Hr	4 – 8	4 – 8
Oxygen Required DO (Reactor) DO (Effluent)	 mg/L mg/L	 0 ~ 6.5 2.0	 0 ~ 6.5 2.0
Minimum Settling Time (before start of decant)	Hr	> 0.6 for decant from TWL downward > 1.0 for fixed points decant	> 0.6 for decant from TWL downward > 1.0 for fixed points decant
Decant Time	Hr	≥ 1.0	≥ 1.0
Decant Depth	M	Max 1.0 (surface decant only)	max 1.5 (surface decant only)
Decant Volume	%	Not more than 25% of volume of Biological Reactor at TWL	Not more than 30% of volume of Biological Reactor at TWL
Decanting Device Loading Rate*	$m^3/m/hr$	≤ 20 for decant from TWL & if SOR(decant) <20 $m^3/m^2.d$ ≤ 15 for decant from TWL & if SOR(decant) <30 $m^3/m^2.d$ ≤ 10 for fixed points decant regardless of SOR	≤ 20 for decant TWL & if SOR(decant) <20 $m^3/m^2.d$ ≤ 15 for decant from TWL & if SOR(decant) <30 $m^3/m^2.d$ ≤ 10 for fixed points decant regardless of SOR
WAS	Kg Sludge/d	$WAS = \frac{\text{Total Solids in System}}{\text{Sludge Age}}$	$WAS = \frac{\text{Total Solids in System}}{\text{Sludge Age}}$
Fill Volume	m^3	$V_{fill} = (Q_P\ m^3/hr \times 1.5hr) + (T_{fill} - 1.5) \times Q_{AVG}$ (if no EQ) $V_{fill} = Q_{AVG} \times T_{fill}$ (if preceded by EQ)	$V_{fill} = (Q_P\ m^3/hr \times 1.5hr) + (T_{fill} - 1.5) \times Q_{AVG}$ (if no EQ) $V_{fill} = Q_{AVG} \times T_{fill}$ (if preceded by EQ)

Summary of SBR Systems

Reviewed design of SBR System:

- Looked into emergence of SBR due to advent of PLC & controllable components and its beneficial uses;
- Described SBR process & its cycle charts;
- Identified various design considerations;
- Provided recommended design parameters;
- Evaluated benefits and draw backs of SBR system;
- Outlined variation of SBR by processes and by equipment;

Today's Topic …

Outline of Contents

- Nut Shell of SBR System
- Control Considerations for SBR System
- Type of O&M for SBR
- IWK Experience in managing O&M of STP

Nut Shell of SBR Systems

In summary,

SBR: combined biological oxidation and clarification within the same reactor in alternative process sequence of cyclical mode.

SBR: emerged as alternative to continuous flow with following benefits:-

- Small land area requirements;
- Less unit processes; thus, less capital & O&M cost;
- Less labor since automated control by PLC's;
- Batch process equalized variation and shock hydraulic & organic load;
- Improve effluent quality: quiescent settling conditions;
- Many parameters removal in a single batch processes;

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Nut Shell of SBR Systems

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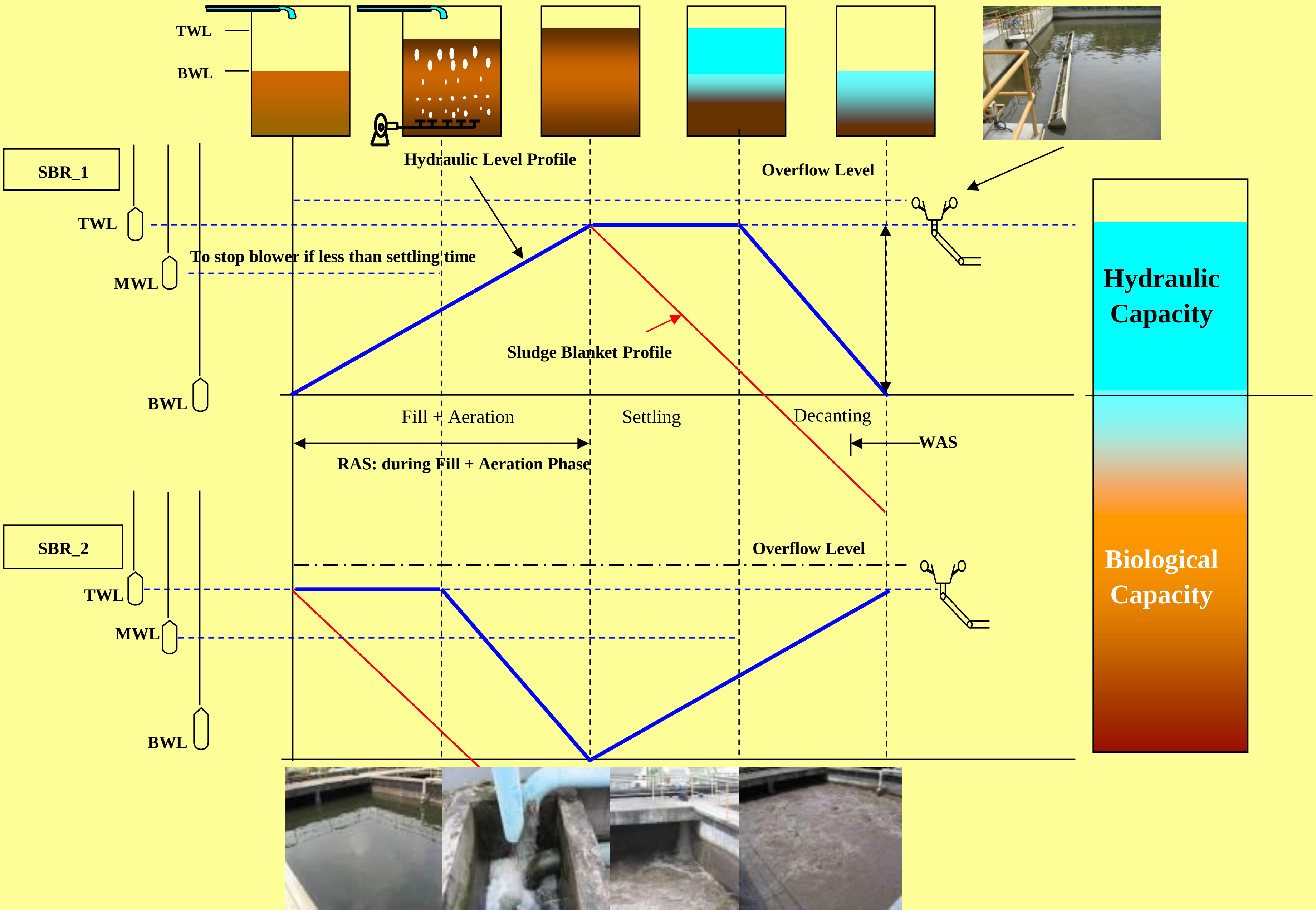
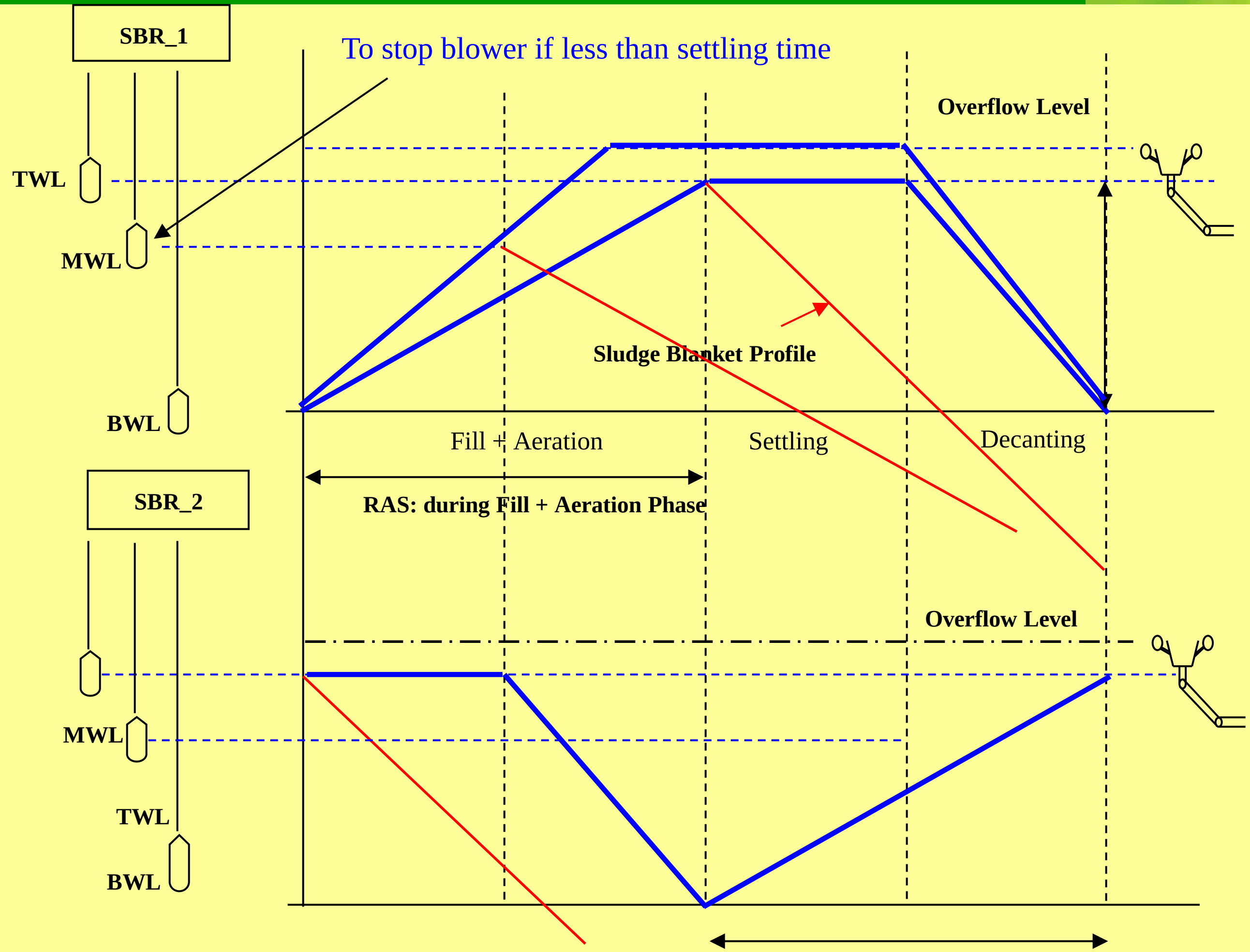


Nut Shell of SBR Systems



Down stream equipment enlarged

When SBR equipment failure:

- Repair become "urgent"
- Replacement complicated

Operator : PLC control

- "faults" panic;
- blur on batch processes;
- Technicians need re-trained PLC literate;

Standardization: Variation equipment

Aeration capacity must also be increased due to aeration fraction ($t_{reaction} / t_{cycle}$) = 0.5 of the total cycle.

Fill				
React				
Settle				
Decant				

Fill				
React				
Settle				
Decant				

Fill				
React				
Settle				
Decant				

Fill				
DAT				
IAT				
Settle				
Decant				

Outline of Contents

Indah Water Syarikat Pembetungan Nasional Anda Your National Sewerage Company

- ☑ **Nut Shell of SBR System**
- ☐ **Control Considerations for SBR System**
- ☐ **Type of O&M for SBR**
- ☐ **IWK Experience in managing O&M of STP**

O&M SBR: Control Parameters

Control consideration of SBR system from operator's point of view:-

- standardization of SBR design and equipment/components employed;
- Higher capacity per unit of time;
- Although the number of equipment has reduced, urgency of repair increased;
- Complexity of operational control increases proportionally with number of reactors and variation of process cycles, and type of equipment employed;
- Significant odor emission initial stage of aeration and proximity to public reduced;

O&M SBR: Control Parameters

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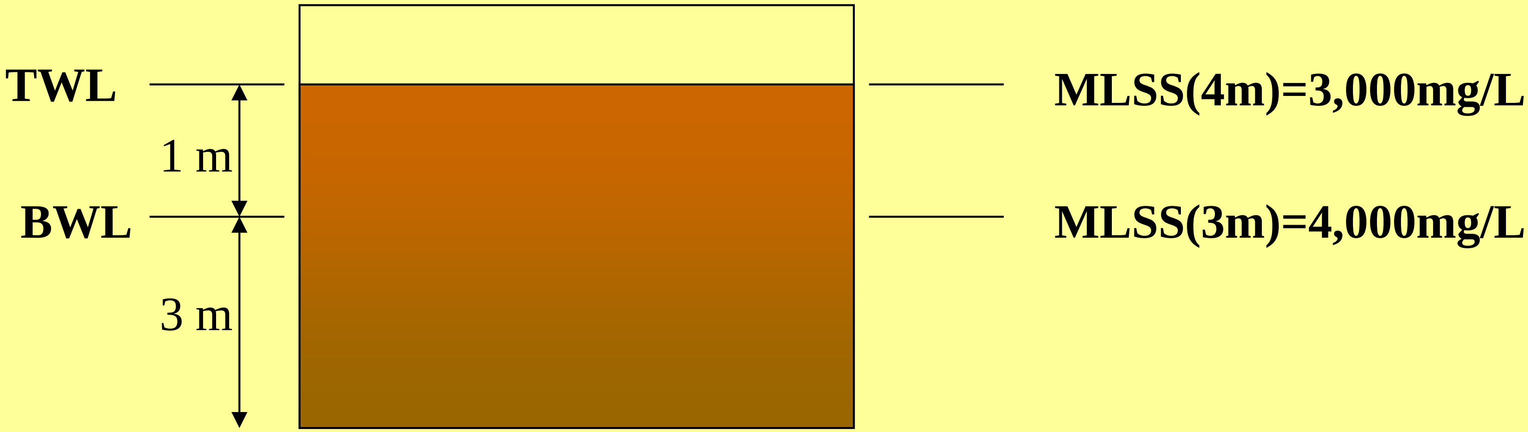
Continue …..

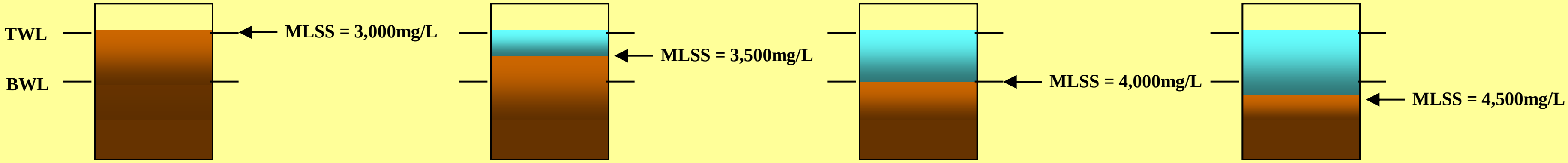
- Power surges attenuation devices due to frequency start-stop requirement;
- More "sensors" to identify actual process cycles;
- Failure of these sensors could be critical to equipment or processes;
- Down stream process sizing significantly increases proportional to hydraulic decanted cycle

O&M SBR: Control Parameters

Process control parameters:-

- Conventional operating parameters for continuous flow processes can no longer simply adoptable to batch processes; (F/M, τ, Sludge age, cycle time)
- Important to note that different water level gives different reading for MLSS(h), SVI(h), D.O(h,t), & other readings;





O&M SBR: Control Parameters

Operator's (IWK) Prospective:-

- **Operational difficulties**
  - Sampling –wait till decanting;
  - Training by system suppliers – lack of operator's expectation;
  - Variation of operating parameters – function of time & level;
- **Control difficulties**
  - Failure of equipment– lack of flexibility to handle variation of control algorithms;
  - Difficult to troubleshoot programming logic bugs;
  - Proprietary design – not possible to alter any variables; Inflexible.
- **Effluent compliance difficulties**
  - Non-true quiescent settling and decanting; (circulation motion due to momentum of fluid motion)
  - Non-true hydraulic surge suppressant; (continuous feed during settling & decanting)

O&M SBR: Control Parameters

Practical Process control parameters:-

- Sludge Age
  - Total sludge / sludge wasted per day
- Color Observation :
  - light brown (young); brown (good); dark brown (old)
- Adjustable flexible time cycles and process time within cycle
  - Extend settling time to improve effluent quality;
  - Adjust aeration time for variation load;
  - Allow anoxic / anaerobic fill to improve nutrient removal;
- SVI
  - Adopt for sludge wasting strategy;
- PLC Reprogramming
  - Improve flexibility of control to handle various conditions:
    - High flow; equipment failures operation mode;

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Operations & Maintenance of SBR Plants: Overview

Treatment Services

- Safety
- Housekeeping
- Basic Maintenance M&E
- Process Optimization
- Minor Repair Works
- Record Measurements
- Sampling (Operational)
- Responsive Maintenance

M&E Services

- Basic Maintenance
- Responsive & Corrective Maintenance
- Planned Preventive Maintenance
- Service & Repair
- Procurement of Parts & Components
- Electrical Maintenance

O&M: SBR System

Frequency of O&M Visitation (As Per OPI)

Type of Treatment Plant	Plant Type	Population Equivalent				
		0 – 500	501 – 2k	2001 – 10k	10,001 – 20k	>20k
Communal Septic Tank	CST	1	1	1	1	1
Communal Septic Tank + PS	CSTPS	4	8	12	20	20
Non Mechanical Plant	IT , OP	2	4	4	8	8
Non Mechanical Plant + PS	ITPS, OPPS	4	8	12	20	20
Mechanical Plant Media	BD, BF, BS, RBC, TF	4	8	12	20	Manned Plant
Mechanical Plant Media + PS		4	8	12	20	
Mechanical Plant Non-Media	AB, AL, AS, EA, LEA, IDEA, HK, OD, SATS, SBR, UASB	4	12	12	20	Manned Plant
Mechanical Plant Non-Media + PS		4	12	12	20	
Network Pumping Station	NPS	4	4	8	8	12

O&M: SBR System

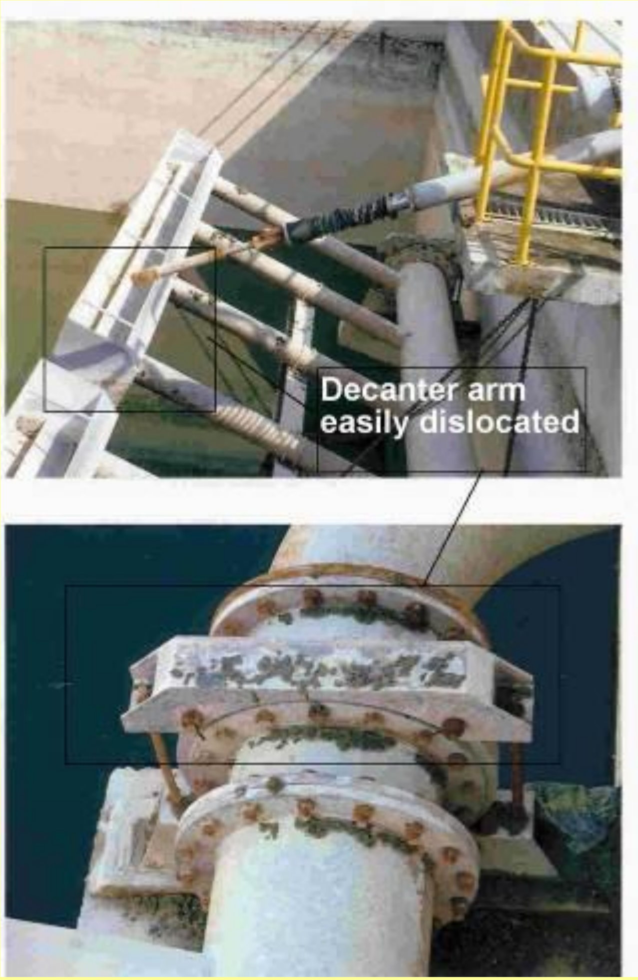
Service & repair works:

SBR Decanter:
Repair of decanter shaft, shaft gear box and motor;

Aeration Device:
Repair / replace of diffusers, blowers, gear boxes, and others;

Actuators:
Repair / replace of actuator valves for air blowers, SBR feed valves, and RAS/WAS valves, etc..

Sensors:
Replace, adjustment and testing functionality of various sensors to/from ensure I/O to PLC is correct.



O&M: SBR System

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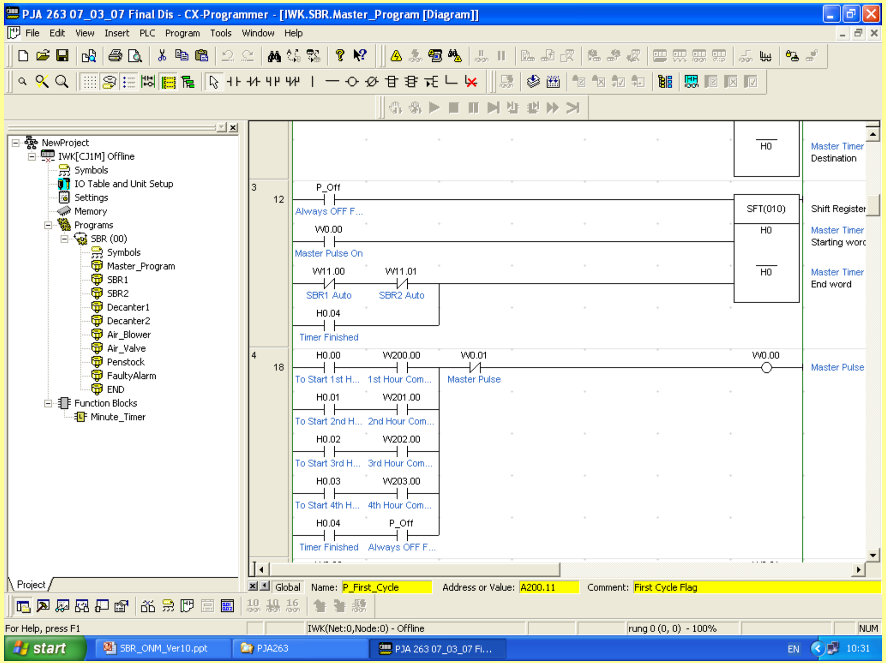
Improvement Works: Control Panel, parts replacement, PLC re-programming

Improvement Works :

- Programming & installation of sensors;
- Re-programming to improve operability to cater various equipment breakdown handling procedures;
- Conversion of hard wired PLC control;
- Standardization of ladder logic programming;



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O&M: IWK Experience

STP in Malaysia:

- Largely dispersed or scattered on-site treatment works;
- Large distribution and high variation of sewerage systems;
- Large variation of treatment system within the similar treatment attributes;
- Rapid construction growth of sewerage treatment plants since 1999.

O&M: IWK Experience

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Operations & Maintenance Treatment Plants

Treatment Services

Routine Activities:
- Process Operation & Optimization
- Safety inspection / OPI visitation
- Housekeeping, Data Record or Measurements
- Basic M&E Maintenance

Schedule / Responsive Activities:
- Minor C&S / M&E Repair Works
- Sampling (Regulatory/Operational)
- Responsive Maintenance
- Attending to authorities, mass media, politicians, & internal inspections
- Attending to customer complaints

M&E Services

Schedule Activities:
- Planned Preventive Maintenance
- Procurement of Parts & Components
- Procurement of M&E services
- Arrangement & procurement: Term Contractors services

Responsive Activities:
- Responsive & Corrective Maintenance
- Minor Service & Repair for M&E

O&M: IWK Experience

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Monthly Operational Inspections For STP and NPS

No.	Type of STP	Population Equivalent / Minimum Frequency Visitation per Month					
		0-500	501-2k	2,001-5k	5,001-10k	10,001-20k	>20,000
1	**Non-Mechanised Plant** (OP, IT)	2	4	4	4	4	-
2	**Non-Mechanised Plant with M&E equipment** (OPPS,ITPS)	4	4	8	8	8	12
3	**Mechanised Plant with Media and M&E Equipment** (RBC, BF,PEBF,TF, TFSC,BS,BD)	4	8	8	12	20	Manned Plant
4	**Mechanised Plant with M&E equipment but without media** (AL,AB,HK,LEA, SAT, AS, EA,OD,SBR,IDEA, SATS, UASB)	4	8	8	12	20	Manned Plant
5	**Network Pumping Station**	4	4	8	8	8	12

Source: Operations Instruction OPI/001

Operational Strategy for O&M Plants

- **Outsourcing STP O&M:**
  - ground maintenance (grass cutting, cleaning works, etc);
  - screenings cleaning & garbage disposal, sludge removal;

- **IWK Teams :**
  - Process operation & optimization;
  - Process control (SVI, D.O., sampling, etc.) & record
  - General equipment PPM (greasing, replacement of consumables, etc.)

Outsource (Others):

- Grass Cutting
- Security Services
- Rubbished Disposal
- Mechanical & Electrical Maintenance / repair
- Supply Electrical Component, tools, consumables
- Clear Sludge from Sand Drying Beds & Disposal
- Minor repair Civil Works (inclusive of fencing repair, drain works, etc.)

O&M: IWK Experience

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Remarks on O&M Outsourcing

Item	Good O	Average Δ	Poor X	Notes / Remarks
Process knowledge			X	No formal training
Provision training			X	Unwilling to send operators to training due to their education background & being a foreigner.
Safety tools and gears		Δ		Moderate safety awareness; availability of safety gears are limited.
Communications skills Paper Works		Δ	X	Mostly operators with little education background. Poor in paper work (basically done by supervisors)
Knowledge of equipment			X	Poor knowledge of equipment maintenance
Responsive Works		Δ	X	O&M teams try to comply with visitation for claim purposes rather resolving responsive issues at hand
Pool resources		Δ	X	Limited to few big O&M contractors; others O&M contractors try to maximize profit;
Electrical / control system			X	Practically not knowledge in control systems;
Ground Maintenance & Cleaning Works	O			Contractors are more attentive to work;

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Summary

O&M of SBR system

- Less labor operation but higher skills & knowledge required;
- Transient parameters must be adopted carefully: level and time dependence;
- SBR processes / equipment variation: need standardization, improvement of control algorithms to cater for equipment abnormal conditions;

Management of O&M of STP

- Considerations for logistic, frequency, size and types O&M;
- Consideration of operational strategies to overcome resources needed for proper O&M of STP to meet regulatory effluent compliances.