OPERATING GUIDELINES
&
MAINTENANCE MANUAL

FOR

WPL BESST

Biological Engineered Single Sludge Treatment

Anywhere WwTW
Anyplace

WPL CONTRACT No. : CN-#######

ISSUE A
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WPL LTD. UNITS 1 & 2 ASTON ROAD, WATERLOOVILLE, HAMPSHIRE, PO7 7UX, 02392 242 600 FAX02392 242 624

OPERATION AND MAINTENANCE OF WPL BESST PLANTS

INDEX

1.	HEALTH AND SAFETY
2.	INTRODUCTION
3.	OPERATION
4.	CONTROL PHILOSOPHY
5.	MAINTENANCE
6.	TESTING
7.	TROUBLESHOOTING
8.	OPERATOR CHECKLIST
9.	EQUIPMENT
10.	SUPPLIERS
11.	SPARES
12.	NOMENCLATURE
13.	CONTACT

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1. HEALTH AND SAFETY

United Kingdom Health and Safety at Work Act 1974

Section 6a of this act requires manufacturers to advise their customers on the safety and the handling precautions to be observed when operating, maintaining and servicing their products.

The user's attention is drawn to the following:

i) All the sections of this manual must be read before working on the equipment.
ii) Suitably trained and qualified personnel must carry out installation.
iii) Normal safety precautions must be taken and appropriate procedures observed to avoid accidents.

REFER TO WPL LTD. FOR ANY TECHNICAL ADVICE OR PRODUCT INFORMATION.

Health

The following is extracted from a health-warning card supplied to all WPL Ltd. staff. It is the client's responsibility to ensure that all necessary protective clothing/ equipment is available.

Leptospirosis
There are two types of Leptospirosis that affect people in the UK:
i) Weils disease. This is a serious infection transmitted to humans by contact with soil, water or sewage that has been contaminated with urine from infected rats.

ii) Hardjo-type Leptospirosis that is transmitted from cattle to humans.

Typical symptoms?
Both diseases start with flu-like illness with a persistent and severe headache, muscle pains and vomiting. Jaundice appears about the fourth day of illness.

How is it caught?
The disease can enter your body through cuts and scratches and through the lining of the mouth, throat and eyes.

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Sensible Precautions

After having worked in sewage or with anything contaminated with sewage, wash your hands and forearms thoroughly with soap and water. If your clothing or boots are contaminated with sewage, wash thoroughly after handling them.

Take immediate action to wash thoroughly, with clean water, any cut, scratch or abrasion of the skin prior to applying a protective covering.

DO NOT handle food, drink or smoking material without first washing your hands.

If you contract the symptoms described after coming into contact with sewage, report to your doctor immediately and advise him/her of the circumstances.

Safety

Sewage gases are potentially explosive and toxic. DO NOT enter any of the below ground compartments of the WPL BESST.

Before carrying out any maintenance work, the equipment must be electrically isolated.

Do not leave covers open for any longer than necessary. Temporary barriers and warning signs should be erected around any open covers or manholes as appropriate.

Any visiting personnel must report to the site office on arrival and fully acquaint themselves with the safety regulations applicable.

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2. INTRODUCTION

This manual provides basic procedures for the operation and maintenance of the WPL BESST. It is intended as a supplement to operator training for reliable and correct operation of the plant.

The WPL BESST range of package treatment plants has been designed to treat the effluent from the range of 100 to 15000 persons. The BESST is intended to serve remote rural communities, such as housing developments, hotels, camping and caravan sites, motorway services areas and any facility not connected to mains sewer.

The process used within the BESST has been developed to meet the more stringent discharge consents as imposed by the Environment Agency, with particular reference to low ammonia levels and nutrient removal. The BESST can achieve ammonia standards of 1mg/l. The specific design consent for the system will determine the standard of treatment that a plant may attain. The Anywhere plant has been designed to solely treat the influent to a consent standard of ##mg/l BOD, ##mg/l SS, #mg/l NH_4-N, ##mg/l TON and #mg/l TP (chemically assisted).

2.1 Process Background

The BESST process is a modification of conventional activated sludge that incorporates an anoxic selector zone and an upflow sludge blanket clarifier. The BESST process may be designed for 1) carbonaceous (BOD) removal 2) BOD removal and nitrification 3) BOD removal nitrification, and denitrification and 4) BOD removal, nitrification/denitrification and phosphorous removal. For carbonaceous removal, the anoxic zone serves as a “selector zone” that conditions the mixed liquor to improve settleability and to control filamentous organism growth.

For nitrification, denitrification and phosphorous removal designs, the anoxic zone provides the necessary conditions for dissimilarity nitrate reduction and phosphorous removal by “luxury uptake”. In this process, ammonia nitrogen is oxidized to nitrite and then to nitrate by Nitrosomonas and Nitrobacter bacteria, respectfully in the aeration zone. The nitrate is then recycled to the anoxic zone where the nitrate is reduced by dissimilarity nitrate reduction. The denitrification process is the same as that in use in the Modified Ludzack-Ettinger (MLE) system. In this reaction, the incoming BOD

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serves as the carbon source or electron donor for the reduction of nitrate to elemental nitrogen.

The phosphorous removal mechanism in this process is the same as that employed in the Phostrip and modified Bardenpho processes. In the BESST process, fermentation of soluble BOD occurs in the anaerobic or anoxic zone. The fermentation products are selectively used or assimilated by a special group of microorganisms that are capable of storing phosphorous. During the aerobic stage of treatment, soluble phosphorous is taken up by the population of the phosphorous storing bacteria (Acinetabacter) that was developed in the anoxic zone.

The assimilated phosphorous is then removed from the system as excess biomass or waste sludge. The amount and rate of phosphorous removal depends primarily on the BOD/P ratio of the influent wastewater.

The BESST process utilises a unique patented upflow sludge blanket clarifier. The upflow blanket clarifier utilizes a trapezoidal shape where the mixed liquor enters the bottom of the clarifier thorough a specially designed baffle where hydraulically induced flocculation occurs. The trapezoidal clarifier shape provides for a steadily increasing surface area from the bottom to the top of the clarifier. This permits a gradually decreasing vertical velocity gradient within the clarifier. The "top surface area" clarifier overflow rate is 0.25 – 0.4 m^3/m^2.hr at average daily design flow. The clarifier is normally designed for a daily peak flow rate of 3 times the average flow ratio which translates to a peak "top surface" clarifier overflow rate of 0.75 – 1.2 m^3/m^2.hr which is very conservative. The clarifier also includes a unique baffle arrangement to allow sludge withdrawal at the bottom of the clarifier. The sludge withdrawal design also incorporates the internal recycle between the aerobic and anoxic zone. The normal design recycle/sludge withdrawal rate is 4 times the average daily flow. This high sludge withdrawal rate from the clarifier bottom creates a downward velocity gradient within the clarifier that significantly improves the hydraulic efficiency of the clarifier compared to a conventional clarifier.

The internal recycle between the aeration zone and the anoxic zone provides recycle BOD that is required for endogenously supported nitrate reduction. This internal recycle of mixed liquor also provides for recycle of phosphorous removal organisms developed in the anoxic zone that are then carried into the aeration zone for phosphorous uptake. The recycle ratio is

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established based on the influent BOD/total phosphorous/ammonia nitrogen ratio. The recycle ratio of 4.0 provides for a 25% - 35% safety factor for domestic wastewater.

2.2 Design

The major process design parameters for this process depends on 1) wastewater strength and biodegradability 2) wastewater temperature, influent and effluent BOD, N, and P concentration. Typical HRT's for the aeration zone range from 6 to 30 hrs. The HRT's for the anoxic zone typically range from 1 to 2 hrs for a selector zone used for carbonaceous removal and 2-8 hrs for biological phosphorous removal and denitrification. The design SRT is controlled by the temperature dependent nitrification and BOD removal kinetics and the design effluent NH4-N requirements. The operating SRT is normally maintained at 50% to 100% greater than the design SRT at a operating temperature to provide a safety factor and to accommodate changes in influent wastewater characteristics. (Please note that SRT is both a design parameter and a process control parameter). The WPL BESST plant has been designed to operate initially according to the following criteria:

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BESST DESIGN

Influent Conditions:-

Population Equivalent	###
Total Daily Flow	## m^3/day
Peak Flow to Treatment	## l/s
Max. BOD Load	## kg/day.
Max BOD Concentration	###mg/l
Max S.S Load	##kg/day.
Max SS Concentration	### mg/l
Max. NH_3 Load	## kg/day.
Max NH_3 Concentration	##mg/l
Desludge frequency (Separate sludge storage)	## days
pH	7 to 9

No Toxic substances or biological inhibitors are to be present in the influent.

Effluent Discharge Standard:-

BOD5 (ATU)	## mg/l
Suspended Solids	## mg/l
Ammoniacal nitrogen	# mg/l (Subject to sufficient alkalinity being present in the raw sewage)
Total Nitrogen	## mg/l
Total Phosphorus	# mg/l

Specification:-

No. Reactors:	# off
Anoxic Volume:	## m^3
Aerobic Volume:	## m^3
Clarifier Volume:	## m^3

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2.3 Process Description

Screened raw sewage enters the plant through an inlet located in the plant end wall. Flow then enters the anoxic compartment of the bioreactor where the influent is mixed with activated sludge from the bottom of the clarifier by means of an air lift pump. The mixed liquor then underflows into the aeration compartment in a plug flow manner through a transfer pipe to the far end of the aerobic zone to prevent short circuiting. It is aerated in the aerobic compartment by fine bubble air diffusers. Aerated mixed liquor then flows to the bottom of the sludge blanket filtration clarifier where sludge flocs and water are separated. After separation the clear water overflows into a weir trough and discharges to the outlet.

Excess sludge is periodically transferred by means of an airlift pump to a sludge thickening storage compartment where it is thickened (digested) while the supernatant is transferred back to the anoxic compartment by means of a transfer pipe. Thickened sludge is periodically removed for suitable disposal.

The air for biological oxidation and to operate the air lift pumps is provided by positive displacement air blowers.

2.4 Installation

The BESST sewage treatment plant is a complete factory prefabricated plant shipped and ready to be set on the foundation pad. There are however, certain important details that must be taken care of by the owner or contractor before and after the plant arrives at the job site. NOTE: Due to the size of some systems, the equipment may be shipped in several pieces and require field erection.

2.4.1 Offloading

The purchaser may be responsible for off-loading at the nearest roadway to site that is suitable for heavy goods vehicles. A minimum height clearance of 16' 6'' is required. If there are electrical cables overhead ensure there is a means of turning the power off. For off loading from a lorry mounted HIAB there needs to be a firm area for the stabilisers, the total width being a minimum of 15 feet. In most cases, the BESST will be delivered to site directly by low-loader trailer unless otherwise specified. The following are a few final details to check out before the tank arrives.

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1. Ensure that off road access to the site is adequate for the tank size and adequate clearance is provided for a low-loader trailer. Check the excavation (where applicable) and the pad to see that it is clear of all mud, water or debris and that the excavation is clear of spoil piles around the adjacent area for truck and crane operation.

2. Sizing of the crane should be based on both the weight of the heaviest piece of equipment and site conditions. Be sure you have a crane with sufficient capacity to lift and boom the tank over and onto the base pad. The net weight of the BESST plant is ## metric tonnes. The steel tanks have lifting gussets located along each side of the tanks for use with a four leg cable sling with a minimum ten foot legs or spreader bar to prevent undue stress on lifting gussets. Cables and shackles should be supplied with crane or by contractor. WPL Limited will not be responsible for damage to tank due to improper cable or shackle configuration.

If the nearest road access for a heavy goods vehicle is not adjacent to the site, it is the responsibility of the purchaser to arrange transport from the road to the site. If in doubt contact WPL Limited as soon as possible with any queries.

Inspect the unit for any damage to the base before placing on the ground and then inspect the sides. The unit should only be placed on level ground with no sharp stones, bricks etc. as they may damage the base of the unit.

The control panel, blowers and any other electromechanical equipment supplied should be stored in suitable conditions i.e. condensation free.

2.5 Location

The tanks are manufactured from 6mm thick, epoxy coated mild steel for corrosion resistance structural strength and long asset life. These are fully covered with perforated grating to allow process air to circulate from the reactors.

2.5.1 Setting Out

1. Upon arrival of the BESST and ancillary equipment, direct the driver to position the trailer (if possible) so that the discharge end of the tank is placed at the discharge end of the pad.

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2. Carefully rig the tank with lifting slings and position it properly onto the pad in alignment with the anchors.

2. Check to see that tank is level and that inlet and outlet are in proper position and elevation before releasing slings. After tank is anchored to pad, it should be rechecked again to see that it is not more than 10mm out of level in any plane.

3. Blowers and controls to provide air to the biological process are housed in kiosks adjacent to the plant on separate plinths. The hose ducts for blowers and electrical ducting are set below ground level and reference should be made to the contract drawings for correct ducting courses and dimensions.

2.5.2 Below Ground Excavation

After the plant delivery date has been determined, the contractor must ensure that the correct civil drawings for preparing the excavation and tank pad are available. The size of the excavation should be at least 1m wider and longer than the tank dimensions to allow room for anchoring and touch-up painting before back filling.

Spoil must be piled far enough away from the excavation to allow trucks and cranes to operate safely from either side.
Care must be taken to see that the bottom elevation of the excavation is accurate and level and that the concrete pad is smooth and level. The tanks are set on a 25mm bed of sand spread evenly over the plinth, to allow correct levelling and bedding before back filling. This also prevents small stones or irregularities from puncturing the paint surface. Tanks should be as level as practically possible. The foundation pad must be level within 10mm both across the width and along the length to maintain the proper water level in the tank. This is important in order to provide a uniform bearing over the entire tank bottom and to ensure the proper flow of liquids through the plant. Errors in grade or pad surfaces cannot be easily corrected after the tank has been set. Securing the tanks to the concrete plinth is via turnbuckles and eyebolts.

IMPORTANT NOTE:

The tie down arrangement shown on the pad drawing is for alignment only and will not prevent flotation when the plant is empty. If ground water problems exist, consult the project engineer and the factory. The tank must be filled with water immediately after installation. WPL Limited will not be responsible

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for flotation of the tank or damage to the tank as a result of groundwater.

The plant is designed such that it is installed below ground, sited on a concrete plinth (DD-550-205). To prevent anti-floatation and assist in removing standing water, provision for a French drain is recommended.

BEFORE BACK FILLING: Check to see that the following things are done:

1. See that the tank has been securely anchored to the pad on both sides.

2. Check and tighten all drain plugs on the plant. Drain plugs are located on the walls of the tank near the bottom.

3. Touch up all scratches or other damage to tank protective coating.

BACK FILLING

Back filling material should be free as possible from rocks, debris or corrosive materials. Extreme caution must be used to avoid deflecting or pre-stressing tank walls by excessive loads of fill or by using heavy equipment to close to the walls.

GRADING

Great care should be taken in grading around the BESST sewage treatment plant in order to mitigate against problems associated to ground water infiltration. The finish grade should be at least 150mm inches below the top of the plant and the ground should slope away from all four sides of the plant. It is absolutely necessary to keep all surface waters and mud from entering the plant in any way. If ground slope is not possible, a retaining wall should be provided with proper drainage to outfall sewer line. A walkway around the plant will help the appearance and maintenance of the plant. Anything done to prevent or control surface water, mud or detritus from entering the plant will improve maintenance issues and provide the correct conditions for a properly operating sewage treatment plant.

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2.5.3 Above Ground Installation

For installations where the BESST is to be sited above ground level, the contractor must ensure that the correct civil drawings for preparing the tank pad are available.

Care must be taken to see that the concrete pad is smooth and level. The tanks are set on a 25mm bed of sand spread evenly over the plinth, to allow correct levelling and bedding before back filling. This also prevents small stones or irregularities from puncturing the paint surface. Tanks should be as level as practically possible. The foundation pad must be level within 10mm both across the width and along the length to maintain the proper water level in the tank. This is important in order to provide a uniform bearing over the entire tank bottom and to ensure the proper flow of liquids through the plant. Errors in grade or pad surfaces cannot be easily corrected after the tank has been set. Securing the tanks to the concrete plinth is via turnbuckles and eyebolts.

2.6 Connections

Connect inlet and outlet sewer lines. Where flow to the BESST is by gravitational means, it must be ensured that there is a sufficient fall (gradient) from the source to the invert level of the inlet pipe. A fall between 1:40 and 1:100 is usually required to give a self-scouring velocity that prevents blockages in the pipes.

2.7 Ducts and Hose Draw Chambers

Ducts are required for all hose and electrical cable connections between the kiosk and the various sections of the unit. Ducts may also be required between where units are built in more than one section. At the unit end of the ducts a 'Hose Draw Chamber' is required to enable the connections to be made to the unit. The Hose Draw Chamber should be at least 300mm square and of a suitable depth to suit the connections (consisting of a brick/block work chamber with removable access cover circa 300mm square by 300mm deep). Ducts to the kiosk should run uphill if possible to avoid flooding the kiosk with surface water. Feed the hoses down the duct and connect to the bulkhead connectors on the side of the unit. Jubilee clips are either secured to a blower or in the delivery envelope. Cut the air lines to length to allow connection to the blower in the kiosk, ensuring that there are no kinks or sharp bends in the lines. Note: If the distance from the blower to the kiosk is over 10m, it is recommend that the air hose is increased in

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diameter to account for the pressure loss of the excess distance-Consult WPL for further advice

2.8 Electrical Installation

Due to the variance of the sites and installation configurations it is not feasible to state a specific installation configuration to suit all sites. Therefore it is important that the electrical installation is performed by a qualified electrician in accordance with the 16th or later edition of the I.E.E. regulations, with appropriate current protection devices for the site configuration.

The supply to the BESST should have a dedicated circuit incorporating isolation and protection devices to the regulation requirements of the Institute of Electrical Engineers. An earth leakage circuit breaker is recommended and should be incorporated into the supply to the BESST unit (a device with a 30mA maximum trip current is recommended).

N.B. The wiring diagram is in the electrical control panel inside the kiosk. If it is missing or lost please contact WPL for another copy.

2.8.1 Three Phase connection

When the 3-phase supply is switched on ensure the correct rotation of the blowers, as incorrect rotation will cause damage if run for more than a brief check. This check must be done with the all airlines disconnected from the blowers.

IMPORTANT NOTE: IF THE THREE PHASE IS NOT CORRECTLY CONNECTED SERIOUS DAMAGE CAN OCCUR. SHOULD A POWER FAILURE OCCUR ISOLATE THE SUPPLY TO THE UNIT. WHEN POWER IS RECONNECTED ENSURE THE PHASES AND ROTATION ARE CORRECT.

ELECTRICAL CHARACTERISTICS:

The plant has been built per the electrical characteristics shown below. The contractor is to ensure that there have been no changes in power supply since the plant was ordered.

Volt, # phase, ##Hz, power supply for a total of _______ kW motor requirements.

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2.9 Final Assembly

The BESST prefabricated steel sewage treatment plant is shipped from the factory complete with all internal piping, submersible mixer(s), actuated valves and diffusers ready for operation.

As the electrical control panel and the blower motor units are mounted remotely from the plant a suitable concrete foundation pad should be provided for mounting the equipment. This should be sized to suit the kiosk (not normally supplied with a BESST system), above the adjacent surface water level (and the flood plain) to avoid surface water ingress.
Provision for servicing ducts for air lines, cables and mains power should be made. Lay the ducting from kiosk to the unit, mains supply and any pumping chambers or sand filter. When the concrete slab has fully cured secure kiosk to the slab and seal to the concrete with mastic.

Other items or accessories supplied loose should be removed from the delivery vehicle and placed in a safe dry location until ready for installation on the plant. The driver has a copy of the packing list showing the equipment that was shipped with the plant. This should be checked to see if all equipment was received before signing manifest. Please note that any shortage or damage claims must be made in writing within 72 hours from delivery. WPL Limited will not be responsible for any items that were shipped and signed for, but end up missing or damaged at the time of installation.

All controls are pre wired inside a lockable weatherproof control panel. For correct electrical installation of control panel, refer to a competent qualified electrical technician as per section 2.8 with reference to the control panel wiring diagrams.

All blower motors, mixers, dosing systems, accessory items and the electrical control panel are pre wired as far as possible and need only minor connections of component wires to their proper terminal points in the electrical control panel to complete the electrical installation. For screw screen installation, reference should be made to the Screw Screen O&M Manual. Reference should also be made to the air compressor and submersible mixer O&M Manuals for correct installation and maintenance related matters.

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3. OPERATION.

Upon successful completion of commissioning, the WPL LTD BESST will be in operational mode. Little in the form of specialist equipment is required to ensure the process operates within the design parameters.

The operating system itself is self contained within the control panel and associated instrumentation devices. As such for the process to operate correctly, bi-weekly attendance by a trained operative, carrying out the tests and observations as detailed within the proceeding sections, is all that is required.

3.1 Specifications

The nominal flow of sewage will see treatment via three zones, although all processing occurs within a single tank. These three process zones include:

3.1.1 Anoxic Zone

The anoxic compartment is located at the inlet end of the treatment plant, as shown on the contract drawings, and shall receive the raw, screened sewage. The volume of this compartment shall be a minimum of ## m^3. Within this compartment, there shall be #airlift pump(s), #"in diameter, with its suction end directly connected to the bottom of the centrally located clarifier to facilitate the return of sludge to the Anoxic Zone. In addition, located at the bottom of this compartment, there shall be a mixed liquor transfer port that will enable the liquid in this compartment to move, in a plug flow fashion, into the aeration compartment. To assure complete mixing in this compartment at all times, there shall be # submerged mixer with mounting mast and hoist provided. The mixer shall be ________ Model _______; ____ kW, ____V, ___ph, ___Hz.

3.1.2 Clarifier Zone

The clarifier is located in the center of the tank as shown on the contract drawings, and shall divide the anoxic zone from the aeration zone. The clarifier shall be of the self-regulating type relative to flow, with a minimum surface area of ##m^2, and a minimum volume of ##m^3. The primary function of the clarifier will be that of a Biologically Engineered Single Sludge Treatment; separating the sludge floc from the clear, treated water.

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On the aeration zone side of the clarifier wall, and as shown on the contract drawings, there shall be an inlet structure to the clarifier which will be of sufficient size to allow a stream of aerated wastewater to enter at the bottom of the clarifier cone where the sludge floc will begin to develop. Specific dimensions of this inlet structure shall be as shown on the drawings.
At the clarifier surface and centered in that tank as shown on the drawings, will be a baffled effluent trough with an adjustable steel weir. Effluent from this trough will flow by gravity to downstream processes as required.

The clarifier shall be fabricated of structural grade steel, polypropylene or PVC panels with an aluminum framework supporting grid.

3.1.3 Aeration Zone

The aeration zone has a minimum capacity of #m^3, and will be complete with air header, diffuser drops with adjustable gas cocks, and fine bubble diffusers in sufficient quantity and placement to assure even distribution throughout the compartment. Each air diffuser shall be connected to the air header with a 1 1/4" steel drop pipe. The drop pipe shall be connected to the air header in a manner that will permit raising the drop pipe and diffusion device above the water surface quickly and without disturbing air flow to the other diffusers, or requiring emptying of the compartment contents. The air diffusion device shall have a mass transfer efficiency such that an adequate supply of oxygen is maintained in the aeration tank to treat the sewage load for which the plant is designed.

3.1.4 Sludge Storage Tank

A sludge storage tank is provided to hold wasted sludge prior to off-site disposal. The tank is (integral to) (separate from) the main treatment plant, and has a volume of # m^3, giving a sludge storage time of # days based on the influent conditions given above. The tank is (un-)aerated, and will have a supernatant return "T" pipe positioned to facilitate gravity flow of the returned supernatant to the anoxic zone of the treatment plant.

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3.1.5 Screw Screen

An inlet screw screen is provided for removal of large debris, ragging and other screenings that might otherwise interfere and damage the submersible mixers housed within the BESST unit. The screen operates automatically and requires connection with a water supply or final effluent pumping station for washing of the screen surface.

3.1.6 Dosing System

A chemical dosing equipment is supplied to dose (ferric sulphate) (sodium hydroxide) (nutrients) into the aeration zone. The equipment includes a chemical storage tank of volume ###l, a top entry mounted mixer integral to the tank rotating at ####rpm with a ###mm shaft length and a diaphragm metering pump operating at #litres/hour at #bar and adjustable stroke rate from 0 – 100%.

3.1.7 Dosing System

A chemical dosing equipment is supplied to dose (ferric sulphate) (sodium hydroxide) (nutrients) into the aeration zone. The equipment includes a chemical storage tank of volume ###l, a top entry mounted mixer integral to the tank rotating at ####rpm with a ###mm shaft length and a diaphragm metering pump operating at #litres/hour at #bar and adjustable stroke rate from 0 – 100%.

3.2 Process Input Variables

The operating parameters are maintained within their optimum range by controlling the process input variables listed below and in table 1.

3.2.1 Oxygen Input

Considering the significance of dissolved oxygen concentrations for the processes of carbonaceous removal, nitrification and denitrification, the importance of careful and accurate oxygen management is critical. Sufficient air must be supplied to ensure complete nitrification, however excessive aeration must be avoided so as not to inhibit denitrification. This may be done by monitoring the final effluent for ammonia, nitrate and nitrogen concentrations which provide a sensitive measure as to the required oxygen input.

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High ammonia (>5 mg/l) and low nitrite-nitrate concentrations indicate the nitrification process is not operating due to insufficient oxygen to completely oxidize ammonia. Low ammonia (<5 mg/l) and high nitrite-nitrate nitrogen concentrations indicate that denitrification is not functioning due to over aeration. This may also be caused by low temperature. Adjustments to the supply of oxygen should be made and air can be taken or added to that supplied to the scum skimmer. If over aeration occurs, air should be released to the scum skimmer through opening the supply valve and vice versa. Adjustments should be made gradually until the desired DO is obtained.

3.2.2 RAS

(Return Activated Sludge): The recycle ratio is the plant's activated sludge recycle flow rate to the volumetric flow rate of the plant. BESST plants use a high RAS rate (3.5:1 and above) which facilitate the high rate of denitrification and also serve to accommodate high peak flows.

3.2.3 WAS

(Waste Activated Sludge): The plant's wasting regime should be aimed at maintaining a sludge age of between 25 to 35 days. The quantity of sludge wasted will vary taking into account the variations in sludge concentration.

Table 1: Process Input Variables at Design Average Loading Conditions

Parameter			Optimum Range
Oxygen Input as Air		[m3/h]	##
Returned Activated Sludge Rate (RAS)	RAS	[m3/h]	#
Waste Activated Sludge Rate (WAS)	WAS	{m3/d]	## to ##

To quantify the daily sludge inventory the following calculations may be followed.

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1. Determine the current TSS concentration at the wasting point at the bottom of the sludge blanket clarifier, or use a typical measured waste sludge concentration from the plant. Usually twice the operating mixed liquor concentration is a good starting point.

   e.g) WAS mg/l = 3500mg/l * 2 = 7000mg/l = 0.7% DS

2. Assume a sludge generation rate (usually 0.6kg / kgBOD). Determine the amount to be wasted each day as:

   BOD removed (mg/l) = BOD influent- BOD effluent

   Determine the plant influent flowrate, Q in m^3/day

   Determine the daily volume of sludge to be wasted

   WAS (m^3/d) = (BOD removed (mg/l) * 0.6 * Q) / WAS (mg/l)

3. In order to gain a better understanding of actual plant operating parameters the actual WAS solids concentrations and sludge yield values may be calculated for a particular site.
4. The wasting rate may then be adjusted by the two part timer on the control panel in order to attain the desired MLSS concentration within the reactor. Less frequent desludging may also be employed although no more than 20% of the tank sludge should be withdrawn at one time.
5. Please consult WPL prior to commencing procedure.

3.2.4 Clarifier Operation

Separation of water from the sludge takes place in the half triangle shaped BESST clarifier located in the bioreactor. The BESST clarifier has a high specific rate of separation and is hydraulically self regulating. The mixture of microbial cells and water enters at the bottom and, as it rises, upward velocity decreases until the sludge flocs become stationary forming a filter media, effectively filtering out colloid and very fine particles. Furthermore, the higher the flow, the higher sludge flocs rise and the larger the filtration area becomes. There should be a very distinct interface between the effluent and the sludge blanket. At peak flows the interface should never rise above 250mm below the effluent weir.

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While the operation of the clarifier is fully self regulating it is important that it be regularly inspected and developing problems, if any, alleviated. Anoxic conditions within the clarifier, perhaps due to no RAS or influent flows, must be avoided. Otherwise nitrogen gas bubbles formed by denitrification will cause rising sludge and reduce effluent quality. It is also possible that the water surface of the clarifier will contain carried over materials, such as light plastic, corn kernels, fats and oils. These must be regularly skimmed off the surface of the clarifier by turning on the air supply to the airlift scum skimmer provided for this purpose. (The system will “adsorb” as much as 30 mg/l of the influent fats, oils, and greases.)

3.2.5 Desludging

Sludge wasting will be governed by the requirements of the sludge age maintenance and as such subject to influent flow characteristics. It should always be done while aeration is on and adjusted from time to time based on the MLSS concentration trending as determined by SSV monitoring. Due to the anticipated slow build up of the plant loading, there will be no sludge draw off in its early life as it will take some time before the plant reaches the desired MLSS concentration of 2,000 to 5,000 mg/l.

An air lift pump which draws mixed liquor from the bottom of the clarifier is installed for wasting sludge. This airlift is controlled by an air control valve located at the air manifold. The discharge line of the airlift is equipped with valves which allows for sludge discharge either to the sludge storage/thickener or the anoxic tank. When sludge is wasted to the sludge storage/thickener it must be periodically removed and disposed of. Again, the frequency of removal will depend on the plant loading and a relatively long period before the first sludge removal need is anticipated.

3.2.6 Influent Composition

To ensure the plant’s trouble free operation, it is essential that any materials that can harm the treatment biology such as, but not limited to, the following are not present in the influent.

- Oil and fat (in concentrations higher than 30 mg/l)
- Paints and paint thinner
- Acids and alkalis
- Petroleum products
- High strength cleaners and detergents

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- Large quantities of chlorine (e.g. pool chlorine)

To reduce the frequency or eliminate the need for cleaning material debris from the screening device , it is recommended that the following material be kept out of the influent wastewater.

- Plastic material
- Rubber materials
- Textiles
- Sanitary napkins

3.3 Commissioning

Always consult equipment manuals prior to individual equipment start and operation. The plant is started up by using seed activated sludge from an extended aeration biological treatment plant, ideally another WPL BESST plant, sludge volume index of which is no higher than 150 to 180 ml/g with a sludge age of no less than 15 days. Seed activated sludge must be fresh; ensure that seed sludge is used within 24 hours of collection or that the transport containers are aerated. (Improper seed sludge may significantly increase the startup time). The seed sludge will typically be taken from the aeration zone and thickened prior to transportation. Upon arrival on site the seed sludge is diluted and added to the water filled anoxic zone of the bioreactor. Up to one third of the total tank volume should be used to seed the BESST. The settled sludge volume (SSV) after seeding should be 300 to 400 ml/l.

INITIAL STARTUP PROCEDURE

1. Fill bioreactor with water. (Avoid using chlorinated water for initial fill up.)
2. Start air blower and adjust flows to RAS air lift pump and diffuser drops. RAS flow should be equal to 3.5 to 4.5 times design flow.
3. Dilute seed sludge and pump it gradually to the anoxic compartment. Ensure sludge does not overflow.
4. The plant is now ready to receive wastewater. Plant loading should start with a minimum of delay. Do not seed plant if it will be more than 1 day before loading the plant with raw sewage.

Note: The plants like to be loaded. Under loaded plants will take much longer to startup and will not operate or meet the effluent quality criteria unless fed.

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The plant startup requires a degree of balancing the plant variables against the observed loading rates. No two plants loads are ever alike and the presetting of variables to their optimum is not possible. The plant must be closely observed for a period of time and based on the observations input variables adjusted from time to time as needed.

4. CONTROL PHILOSOPHY

(Refer to P&ID drawing number DD-550-###)

4.1 Pump Station

Raw sewage enters the pumping station via a gravity discharge pipe. The pump station is fitted with a duplex pump set that can be operated in duty/assist or duty/standby mode. The pump station is fitted out with four float switches/level sensors. The lowest float switch, marked CI will act as the “Common Inhibit” and should the water level in the pump station fall to the set point on which this contact will be made, both pumps will be given the signal to stop pumping. The next float switch up from this, marked M1 S will act as “Pump 1 Start” and once the water level reaches this point, the contact will be made and pump 1 will start. The next float switch up from this, marked M2 S will act as “Pump 2 Start” and once the water level reaches this point, the contact will be made and pump 2 will assist pump 1 in the event that this pump is getting beaten or take over as duty pump in the event that this pump has tripped out or has some other mechanical problem. The highest float switch, marked H will act as a high level alarm that can be series connected to the common alarm and beacon in the control panel.
Failure of either M1 or M2 will be detected by overload and will cause a common alarm that will cause the beacon off the control panel to light.

4.2 Flow Control Box

Pumped sewage from the P/Stn will be lifted up to a WPL flow control box via an ##mm rising main. Flows in excess of 3DWF or ##l/s will be returned to the pumping station on a ###mm gravity return drain. The adjustable plate on the flow control box will be set on site to achieve this pass forward flow by referencing against the display on the Pulsar Ultra3. This calibration should be carried out when the pump station is at its highest level as this would deliver the greatest suction head.

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4.3 Screen

Crude sewage from the flow control box will then gravitate through the In-Eko inlet screw screen 400_CS_600_B. The screen is controlled by a Siemens LOGO and M10 is activated on two philosophies depending on which occurs first. One is based on time intervals (set by user or factory default) and the other is based on head loss across the screen. A level probe upstream of the screen will sense whether the upstream head is high enough to initiate the screw to turn to enable screenings compacting and washing. On the same philosophy, the mains water solenoid valve V17 will open to enable backwashing of the screen.

4.4 BESST

Screened influent enters the BESST system through a 6” inlet pipe. The screened sewage enters the anoxic zone. The floc in the anoxic zone is suspended by a duty only mixer M9, failure detected by overload. The mixer will operate continuously.

The anoxic liquor passes to the aerated section through the 10” connection pipe, flow is by gravitational means. The pipe passes to the end of the aeration zone preventing short circuiting.

The aeration section is aerated by a duty only blower M3 using fine bubble diffusers; each row of diffusers is on an isolatable removable drop leg. The airflow to each drop leg can be individually throttled to achieve a balanced air distribution by adjusting valves V7 through to V11. Excess air that is not required to satisfy the oxygen demand in the Aeration Zone is surplassed to both the scum skimmer V12 and to maintain aerobic conditions in the sludge storage zone by adjusting V13.

The process and airlift RAS blowers M3 and M4 respectively work on a duty only basis, failure is detected by an overload and both compressors will operate continuously.

Aerated liquor passes into the base of the clarifier by hydrostatic head and displacement. The sludge blanket detector is present in the clarifier with the Partech Soli-Tech 20 sensor of the detector (SbE) fixed approximately ###mm below top water level. The sludge blanket detector is a limit switch that detects the sludge/supernatant interface on attenuation of light and the unit will operate as an emergency relief system should the blanket encroach upon the weir overflow level. Should the sludge blanket cause the transducer to make a relay contact, a pulsed output will

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be directed to the WAS actuated dump valve M8 to open. Note that M8 is normally closed and is an on/off type actuator. M8 will close again once the sludge blanket drops and the transducer SbE no longer detects it. The Partech 8100 sludge blanket monitor SbIT will give a high blanket alarm when the blanket is detected and this will be in series with the common alarm on the control panel and cause the beacon to light. The common alarm and beacon will come off when the blanket drops again. The Partech 8100 sludge blanket monitor SbIT also features a delay control that can be adjusted from 0 – ## seconds to prevent false alarms being triggered by unrepresentative debris. It is advised that this be set to ## seconds.

Sludge is periodically wasted to the sludge storage zone by a timer within the control panel that can be adjusted by an operator on the door of the panel. M8 will open for ## mins every # hours as a default setting and close again. (Note the desludge period and the length of the desludge will require a period of commissioning. The plant can run with a MLSS from 2000mg/l to 10,000mg/l. The idea is these parameters can be analysed and crude wastage times determined by the operator/commissioning engineer.) The unit is designed to run at a high sludge age (hence achieving a very old stable sludge) so during the commissioning period, it is advised that the process is allowed to ramp up to the top level. During this period, the operator should override the timer controlling M8 to prevent early wasting and close valve V13 to prevent air escape.

The final effluent passes into the V-notch chamber (external) where the flow out the unit is monitored by a Pulsar dbMach3 transducer FE. Sludge is returned from the clarifier to the anoxic zone by airlift (3”). The airlift is set at 4 times the flow and is controlled by motorised valve M7. If flow rate exceeds average flow, M7 will increase (open) proportionally so that recycle rate is four times influent flow rate. A 4-20mA analogue signal will be sent from the Pulsar Ultra3, FIT to the modulated actuated valve M7 that is scaled to the flow rate. It should be noted that a signal indicating zero flow, 0% or 4mA will specify on the positioner of the actuator M7 a value of 50% open (approximately 75% valve travel). Incidentally, the maximum flow rate monitored by FIT (which should not exceed 1.4l/s due to flow control) will have a volt free value of 20mA and a resultant valve position of 100% open on the actuator M7.

It is important for the proper operation of the process that there be a very short response time (to mitigate hysteresis) between when the flow is detected by FE to increase and for when M7

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should begin to open. This is so as to effectively retain the sludge blanket during periods of flow variation by matching the RAS rate in proportion to the process flow rate. For this reason, the Fill Damping feature on the Pulsar Ultra3 should be left at the default value of 10m/min so that the unit will respond to increases in level (flow) at its maximum rate.

Conversely, it is required that there is a lag corresponding to when the flows to the BESST drop off and how soon after the RAS rate is allowed to reduce. By reducing the Empty Damping on the Pulsar Ultra3 from the default value of 10m/min to ##m/min, the 4-20mA output to actuator M7 will be delayed allowing a higher recycle rate to run following periods of higher flow as a process safety precaution.

The display on the Ultra3 tracks the actual flow rate and not the damped variable.

4.5 Dosing system

The ferric dosing system will be controlled by the Ultra3 flow controller supplied by Pulsar. One of the three relay outputs from the Ultra3 will be utilised to send a single digital pulse for every 100 litres of flow that are logged by the unit. This will then go to a delay function that will allow the run out timer to energise for 10 seconds after which the timer will allow the peristaltic dosing pump M5 to run for 20 seconds. On site jar tests will determine the optimum dosing frequency and pump duration and this may be further refined by adjustments to the stroke rate and stroke length of the peristaltic pump. Based on standard strength sewage of 8mgP/l at an average flow rate of approximately 30l/min, ##ml of ferric chloride at a concentration of ##mg/l should be dosed every ##min. A timer will be used to give the contents of the chemical storage tank a mix every 1 hour (adjustable by operator on control panel door) by the dosing mixer M6 and this can be switched off by the operator by turning a switch on the panel door to save energy or during tank fills.

4.6 Desludging

Following a desludge, valve V13 should be closed to prevent preferential air flow to the sludge storage tank that would compromise process performance. The plant should be monitored and the valve V13 re-opened once the sludge storage zone is more than half full again.

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5. MAINTENANCE MANUAL

Before working on the BESST plant, the relative component must be isolated from the mains supply. Failure to do so may result in serious injury or possible electrocution and death

Proper care and attention must be used at all times, with due regard to safe working practices.

Pumps

Refer to pump manufacturers manual for specific maintenance instructions.
Pump removal should be carried out by two suitably experienced/qualified personnel.
A guide rail and chain is attached to the ducks foot allowing the pump to be lifted from the tank. It is recommended that an A frame and hoist (or similar) is used to carry out this task.

5.1 Maintenance Schedule

General:

a) All tanks should be kept clean of accumulated scum and foam by hosing down with water.
b) Ensure that the tanks are kept completely free of any mud, sand, gravel, rocks, boards and any other foreign matter.
c) Ensure that the tops of the tank walls are always sufficiently above finished grade to prevent surface water from entering the plant.
d) Protective grating is installed on the tanks and should be checked weekly for sensible gaping and that the retaining bars are locked into position.

5.2 Daily Maintenance

a) Check all equipment operation,
b) Clean any accumulated solids from the effluent weir trough or from around the scum baffle. If necessary open fully the scum skimmer for several minutes to clear the clarifier surface.
c) Check compressor motor units for any unusual oil leakage or vibration.
d) Check control panel operation and see that all switches are turned to their proper location

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e) Visual check of entire site

5.3 Weekly Maintenance

a) As per daily maintenance
b) Visually inspect exposed pipes and hoses
c) Ensure grating is correctly located on tank top
d) Carry out weekly MLSS tests. (See 6)
d) Inspect oil level on blowers
e) Inspect blower air filters
f) Check position of actuated valves
g) Inspect sludge blanket detector and wash off any scum/sludge if deposits are present
h) Check operation of inlet screen
i) Check flow meter readings and monitor daily total flows on data logger

5.4 Monthly Maintenance

a) Check compressor air filter and clean when necessary.
b) Hose down sides of tank to clear excess scum
c) Visually inspect bubble pattern whilst aerating. Ensure vigorous and even bubble pattern
d) Check if screenings bin needs to be emptied
e) Check that the V-notch is clear of any solids and that the chamber is clear. Hose down if necessary

5.5 Six Monthly Maintenance

Carry out the monthly checks plus:

a) Change oil on the submersible pumps (if required).
b) Change oil on the submersible mixers.
c) Check that the compressor air inlet filters are clear and knock off any collected dust or replace if necessary.
d) Check the ventilation fan in the compressor housing for correct operation. Check the operating temperature within the kiosks and adjust the thermostatic controls as necessary.
e) Check air manifold and pipework to and in plant for leaks, cure if required.

5.6 Annual Maintenance

a) Remove the air distribution legs and clean as required. Replace the air distribution legs and check the air distribution pattern to ensure it is even and vigorous. Diffuser life span is 5 years plus

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b) Adjust operating strategy where required to suit tank operating conditions.
c) Carry out monthly checks
d) Thoroughly check over all the plant. If there is any scum or grease build up on the sides of the tanks or fittings it should be removed by pressure washing or removed with a wood or plastic scraper. **DO NOT USE A METAL SCRAPER.**
e) Check control panel and fan (if fitted) for correct operation. Service or replace as required.
f) Perform compressor maintenance and change air inlet filter

5.7 As Required Maintenance

a) Compare dosing rate with final effluent quality and make changes to stroke frequency as required.
b) Check all submersible pumps for proper operation (observe flow into tank/manhole).
c) Pump or draw off solids from sludge holding tank as required. The frequency between complete desludging of the SHT has been determined to be every 45 days at design loading (without chemical dosing). This will be longer if the plant is under loaded and up to 1.5 times shorter if ferric salts are being dosed. This however, will be found in practise from site determination, effluent quality analysis and weekly MLSS testing/trending.

5.8 Special Maintenance

SURFACE SCUM AND FOAM

Crisp White Foam – Indicates good condition in reactors but an excessive HRT.

White billowing foam – Normal during start-up due to low flows and low BOD.

Greasy Dark Scum – Some is not unusual and generally not a major concern.

If excessive, may interfere with operation of decanters and level sensors, especially if it freezes in winter. May cause odour problems during warm weather.

Remove scum manually or spray down with a hose attachment.

Check MLSS, increase sludge wasting to bring mixed liquor suspended solids level back down to approximately 3000mg/l

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Some foaming is anticipated particularly during the start-up period and during the normal operation of the reactors. After the mixed liquor has become established foaming will disappear or drop down to a minimal level. Dark brown foam layer approximately 1 to 2 inches thick is normal under standard operation.

Long term steady state operation should not require any special method of foam control

6. TESTING

6.1 Routine Sampling

Take samples in accordance with contractual and regulatory requirements. All sampling and testing should be done in accordance with the latest edition of standard methods.

Recommended tests for the BESST should include:

Influent and Effluent (min freq. in brackets)

BOD	Weekly
COD	Monthly
TSS	Weekly
Ammoniacal Nitrogen	Weekly
Total Phosphorus (if consent applies)	Weekly
TON (effluent only)	Weekly
pH	Biweekly
Temperature	Weekly

Anoxic and Aeration Zones (min freq in brackets)

Dissolved Oxygen	Daily using handheld meter
MLSS (aeration zone only)	Weekly

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MLVSS (aeration zone only)	Monthly
pH	Biweekly
Temperature	Weekly
Jar Test (SVI)(aeration zone only)	Daily initially (then weekly)

IMPORTANT NOTE: Dissolved oxygen should be tested more frequently if loading is high, and during summer operation.

6.2 Process Testing

In order to ensure a plant is operating within design parameters, it is important to maintain good housekeeping of the process, and to carry out routine monitoring of the following parameters in order to ensure successful operation, and effluent quality below consent. The activated sludge treatment relies on simultaneously maintaining a number of operating parameters within specified ranges; the most important operating parameters are listed below.

6.2.1 Solids Retention Time

Sludge age (SRT) is one of the most important parameters. It determines the nature of the bacteria in the system and ensures that the process of nitrification reliably occurs. For this reason a relatively constant sludge age of 25 to 35 days is maintained in the BESST plant and is achieved by wasting a set amount of sludge (WAS) regularly from the clarifier bottom. A sludge age of at least 15 days is sufficient to ensure complete reliable nitrification.

SRT is normally calculated based on aeration zone volume and MLVSS concentration since BOD removal and nitrification kinetics controls the aeration zone volume. Provision is made in the design for measurement of both the internal recycle and sludge wasting (an operation advised to be carried out during commissioning with water). The operating SRT of the BESST process may be increased significantly above the design requirements without sacrificing effluent quality since the “anoxic selector” zone conditions the mixed liquor solids and the upflow sludge blanket clarifier provides a “filtration/flocculation” mechanism to prevent the discharge of pin-point floc normally associated with high SRT systems.

6.2.2 Dissolved Oxygen

The dissolved oxygen (DO) concentration should be maintained at 1.5 to 3.5 mg/l in the aeration zone. This will help to ensure complete nitrification and carbonaceous oxidation and it will help to

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prevent the growth of filamentous bacteria. The blowers are designed to supply more air than required and the flow of air can be regulated by bleeding off air to the scum skimmer. For best results DO measurements should be taken when the influent rate is at average loading.

The Dissolved Oxygen concentration in the anoxic compartment should be as close to zero (0) as possible and should never exceed 0.5 mg/l. DO levels above 0.5 mg/l will inhibit the denitrification process.

Under influent loading conditions less than the design values, the HRT in both the aeration zone and in the anoxic zone will be greater than the design value. Under these conditions, the mixed liquor volatile solids concentration in the system will normally be reduced to meet the process requirements. The DO may be maintained at optimum levels by reducing air supply. The increased HRT in the anoxic zone permits more time for exertion of DO demand and production of anoxic conditions needed for fermentation.

6.2.3 MLSS

MLSS (Mixed Liquor Suspended Solids): MLSS concentration is allowed to vary within the provided range. However, if a consistent either increasing or decreasing trend becomes evident over a period of several weeks then a small decrease or increase in the WAS rate will be required to compensate.

6.2.4 F/M Ratio

F/M (Food to Microorganism) Ratio: The F/M ratio indicates the degree of the plant loading. As the growth rate of microorganisms is proportional to the amount of food available, by maintaining a constant sludge age and allowing the MLSS to vary, The F/M ratio will tend to stabilize.

6.2.5 SSV

SSV (Sludge Settled Volume): Although MLSS should be determined and F/M ratio calculated on a regular basis, day to day changes of the plant operation can be fast determined by settled sludge volume tests. A rough MLSS can be calculated from the SSV by multiplying the value for SSV by ten (10).

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6.2.6 SVI

SVI (Sludge Volume Index): By multiplying the SSV by 1000 and dividing by the MLSS, the plant SVI can be determined. This gives greater information regarding the sludge condition, settleability and compactness of the floc. A high SVI is indicative of a poorly quality sludge, improper operation or at worst the abundance of filamentous organisms.

6.2.7 Alkalinity and pH

If the influent wastewater is not properly buffered it is necessary to add alkalinity to the influent wastewater for the BESST process designed for nitrification and denitrification. The nitrification reaction consumes 7.1 mg/l of alkalinity as $CaCO_3$ for each mg/l of ammoniacal nitrogen oxidised. The denitrification reaction produces 3.57 mg/l of hydroxide alkalinity as $CaCO_3$ for each mg/l of nitrate-nitrogen reduced. For an influent wastewater having 40 mg/l of NH_4-N, the total alkalinity should be 150-200 mg/l to ensure adequate buffering. The pH of the system should always be maintained between 6.5 to 8.5 by the addition of alkalinity when required.

6.2.8 Sludge Colour

As sludge floc starts to develop the mixed liquor should start loosing its gray color and appear light brown. As they continue to build up the flocs should get larger, develop a somewhat earthy odor and the color should change to a rich brown.

6.2.9 Procedure for Jar Testing

This test is the fundamental process test for plant operators and should be done on each reactor. As a minimum this test should be performed weekly

- Obtain a 1000ml plastic graduated cylinder or a wide mouth clear glass jar.
- Fill the container with mixed liquor from the aeration zone.
- Let the container stand undisturbed in the shade for a period of 30mins.
- Observe and record the level to which the solids settle. This is the SSV

The following information can be gathered from the above test:

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The solids should be a medium brown colour, have a grainy appearance, have a musty earthy odour and settle rapidly to a compact state within a period of 15 minutes.If the solids occupy about 30% of the total volume, operation is normal. A lesser volume may indicate less than design organic loading; a greater volume may indicate greater than design organic loading. If solids colour and odour is acceptable, but the sludge does not separate properly, check to see if the appearance tends to be fluffy. This would indicate a bulking sludge and is probably caused by filamentous bacteria. Filamentous bacteria will not settle well, if at all.

This is a common, although troublesome feature of the activated sludge process. If the problem cannot be overcome readily by adjustment of process conditions and ensuring anoxic conditions within the relevant process units, the recommended procedure to correct this condition is to super chlorinate the reactor. Note that this will destroy all bacteriological life in the reactor including filamentous, nitrifiers and denitrifying bacteria. Although drastic, this procedure is the most effective manner of correcting the filamentous condition.

Allow the reactor to operate normally after chlorination and daily repeat the jar test. If the condition persists, repeat the chlorine dosage and observe. A filamentous problem should correct itself in around 1-2 days but due to the severity of this recourse, consultation with WPL should be made before any action is taken.

Table 2: Plant Optimum Operating Parameters

Parameter			Optimum Range
Sludge Age		[days]	25 to 35
Mixed Liquor Suspended Solids	MLSS	[mg/l]	2000 to 6000
Food to Microorganism Ratio	F/M		0.05 to 0.2
Mixed Liquor Dissolved Oxygen (Aeration Zone)	DO	[mg/l]	1.5 to 3.5
Mixed Liquor Dissolved Oxygen (Anoxic Zone)	DO	[mg/l]	<0.5
Settled Sludge Volume @ 30 min. - OPTIMUM	SSV	[ml/l]	400 to 600
Settled Sludge Volume @	SSV	[ml/l]	300

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30 min. - MINIMUM			
Settled Sludge Volume @ 30 min. - MAXIMUM	SSV	[ml/l	800
Sludge Volume Index @ 30 min.	SVI	[ml/g]	90 to 120
Mixed Liquor pH	pH		6.7 to 7.5
Sludge Color			Rich Brown

7. TROUBLE SHOOTING

7.1 Poor BOD Removal

- Ensure appropriate F/M (food : microorganism ratio)
- Ensure appropriate SRT (Solids Retention Time) (Design SRT: # days min)
- System should maintain a dissolved oxygen level of 1.5-3.5mg/l within the aerated zone. If not check blowers, diffusers and air distribution lines.
- Ensure no toxic substances in the influent
- Suspended solids in the effluent (see note below)

7.2 High Effluent Suspended Solids

- Poor settling biomass:

a) Ensure DO in anoxic zone < 0.5mg/l
b) Ensure submersible mixer is operating correctly
c) Waste more sludge, lower MLSS

- Pinfloc

a) SRT too long
b) Over aeration

7.3 Loss of Nitrification (High Effluent Ammonia)

- Assure appropriate F/M ratio and SRT
- Assure appropriate DO conditions
- pH swings or presence of toxics in influent

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7.4 Loss of Denitrification (High Effluent TON)

- Extend anoxic period to incorporate a longer fill mix period.
- Do not overaerate. Reduce supply to aeration zone (check DO concentration). Purge air to scum skimmer.

7.5 Poor Phosphorus Removal (High Effluent TP)

- Same as for denitrification
- Assure proper sludge wasting
- Check for high suspended solids in effluent, take high SS remedial actions.
- Increase chemical dose rate if ferric dosing system supplied

8. OPERATOR CHECKLIST

Always check for methane or hydrogen sulphide gas when working around tanks, confined spaces or when entering rooms where conditions for methane gas formation exist. Always vent before entering.

Site: Check the area around the treatment plant. The grass in the area should be cut at regular intervals. Clean up and remove from the site any accumulated debris.

General: Check equipment and components for corrosion and take preventative measures.

Inlet Screen: Check to see whether the contents of the screenings collection bin needs to be disposed of. Check to see that there are no foreign objects inhibiting the operation of the screw screen. Refer to screen manual for further instructions.

Feed Pump Station: Check the liquid level in the tank and if liquid is present ensure that the pumps are operating properly. Pumps should operate both in the manual (on) position and in the automatic (auto) position as controlled by the float switches. Clean all accumulated debris from the float switches and pumps.

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Flow Control Device: Check to see that the orifice and rectangular weirs are free of accumulated debris and clean as necessary.

Chemical Dosing System: Check to see that there are no leaks around the spigot connection and the dosing fluid is being pumped correctly through the hosing. Monitor the level in the chemical storage tank and re-order chemical when level reaches 20%. Check bund is intact and empty of spilt fluid etc.

Sludge Storage Tank: Check the supernatant overflow pipe and insure that it is flowing freely. Check the level of thickened sludge. A disposal truck should be called when the level of thickened sludge is approximately 80% of tank volume.

Bioreactor Tank: Ensure that the aeration pattern is uniform. Check that the effluent weir is clear. Using the skimmer remove any floating substances from the surface of the clarifier. Check the RAS air lift pipe for correct flow and adjust if necessary. Hose down any sludge buildup on the sides of the tank walls.

Flow Measurement Chamber: Check to see that the V-notch and rectangular weirs are free of accumulated debris and clean as necessary.

Air Blowers: Check air filters and clean or replace if required. Check blowers and motors for excessive vibration, signs of leaking oil and signs of wear. Check and adjust belt tension if necessary (where belt driven blowers supplied). Check oil levels and fill to correct levels if necessary. Oil should be changed at least every six months if not more often (where belt driven blowers supplied). Refer to manufacturers instruction manual attached for further instructions.

Mixers: Check to see that the anoxic compartment mixers are running. Mixers should periodically be removed from the tank to check for presence of foreign objects and corrective action should be taken.

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9. EQUIPMENT SPECIFICATION

9.1 Pumps

Feed Pump(s)	Make/Model
MAX I	##A
PWR.	##KW
O/P	##m^3/hr @ #m

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SERIAL NOS ######-######

Effluent Pumps Make/Model
MAX I ##A
PWR. ##KW
O/P ##m^3/hr @ #m
SERIAL NOS ######-######

Refer to Pump Manuals for detailed pump maintenance instructions.

9.2 Blowers

Process Blower(s) Make/Model
MAX I ##A
PWR. ##KW
O/P ##m^3/hr
SERIAL NOS ######-######

RAS Blower(s) Make/Model
MAX I ##A
PWR. ##KW
O/P ##m^3/hr
SERIAL NOS ######-######

Refer to Blower Manuals for detailed blower maintenance instructions.

9.3 Actuators

WAS Make/Model
MAX I ##A
PWR ##KW
SERIAL Nos ######-######

RAS Make/Model
MAX I ##A
PWR ##KW
SERIAL Nos ######-######

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9.4 Mixers

ANOXIC	SIGMA/APM
MAX I	##A
PWR	##KW
SERIAL Nos	######-

######

9.5 Screw Screen

Inlet	Make/Model
MAX I	##A
PWR	##KW

9.6 Chemical Dosing System (Ferric Chloride)(Nutrient) (pH Correction)

CHEMICAL STORAGE TANK	Etatron
CAPACITY	230 LITRES
DIMENSIONS	610mm ∅ x 870mm H
MATERIAL	MDPE
COLOUR	NATURAL / WHITE
C/W	GRADUATED SCALE
	VENTED SCREW LID

FITTED WITH:

CHEMICAL DOSING PUMP

MODEL	DLXB-MA/A2
MAX. CAPACITY	5 LITRES PER HOUR
MAX. PRESSURE	7 BAR
ADJUSTMENT	0-100%, MANUAL
MATERIALS	PP / VITON / PTFE
POWER SUPPLY	230V 1PH 50HZ

ELECTRIC AGITATOR

MODEL	AF 2/6/4
SHAFT LENGTH	800mm
MATERIALS	SHAFT & IMPELLER – PP COATED STEEL
SPEED	1400 RPM
POWER SUPPLY	230V 1PH 50HZ

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9.7 Ancillary Equipment & Instrumentation

Table 3

Item	Make / Model	Location
Foatswitch(es)	Flygt / ENM-10	Feed pumpstation
Course bubble diffuser	DP-75	Aerated Sludge Tank
Fine bubble diffuser	EDI FlexAir Disc	Aeration Zone
Ultrasonics Head	Pulsar dBmach3	Flow Measurement Chamber
Ultrasonics Controller	Pulsar Ultra3	Control Room
Sludge Blanket Detector Head	Partech IR40	Clarifier
Sludge Blanket Detector Controller	Partech 8100 Monitor	Control Room
Flow Control Chamber	WPL Model DD-111-031	Pre BESST tank
PVC V-Notch Flow Measurement Chamber	WPL Model DD-115-006	Post BESST tank

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10. SUPPLIERS.

ITT FLYGT LTD
Colwick
Nottingham
NG4 2AN tel: 0115 940 0111 fax: 0115 940 0444

GARDNER DENVER ALTON LTD (RIETSCHLE)
Waterbrook Estate
Waterbrook Road
Alton, Hampshire
GU34 2UD tel: 01420 544184 fax: 01420 544183

SIGMA Group
Jana Sigmunda 79
783 50 LUTÍN
Czech Republic tel: 00420 585651111 fax: 00 420 585944258

DIFFUSED GAS TECHNOLOGIES (coarse bubble)
1776 MENTOR AVE
SUITE 360
CINCINNATI
OHIO
45212 tel: 001-513-531-4426 fax: 001-513-531-4436

ETATRON
Moor Farm Offices
East Road
Sleaford
Lincolnshire
NG34 8SP tel: 01529 300567 fax: 01529 300503

ENVIROMENTAL DYNAMICS (fine bubble)
5601 PARIS ROAD
COLUMBIA
MO 65202 tel: 001-573-474-9456 fax: 001-573-474-6988

VALVESTOCK (Actuators)
Shogun House
2 Fielder Drive
Newgate Lane Ind. Estate
Fareham, Hampshire
PO14 1JG tel: 01329 283425 fax: 01329 822741

PULSAR PROCESS MEASUREMENT LTD.
Cardinal Building, Enigma Commercial Centre
Sandy's Road
Malvern
Worcestershire
WR14 1JJ tel: 0870 6039112 fax: 0870 6039114

PARTECH LTD
Charlestown
St Austell
Cornwall
PL25 3NN tel: 01726 879800 fax: 01726 879801

11. SPARES REQUIREMENT.

11.1 Consumables.

Oil 10 litres-Submersible Mixer
Ferric Chloride (Mistrale 600) – Chemical Dosing System
Screen sacks

11.2 Recommended 1st and 2nd line spares:

Blower Air Filters
Type ####……..… # off
Blower Air Filters
Type ####……..… # off

11.3 Suggested 3rd line spares

As 1st and 2nd line plus
Coarse bubble diffusers. 10 off Operational life 5 years plus. contact WPL Ltd for re order
Fine bubble diffusers. 10 off

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Major pieces of equipment are not considered a spares item

12. NOMENCLATURE:

BOD	:	Biochemical Oxygen Demand
BESST	:	Biological Engineered Single Sludge Treatment
DO	:	Dissolved Oxygen
HRT	:	Hydraulic Retention Time
Mg/l	:	Milligrams per litre
MLSS	:	Mixed Liquor Suspended Solids
MLVSS	:	Mixed Liquor Volatile Suspended Solids
NH_3	:	Ammonia
RAS	:	Return activated sludge
SRT	:	Solids Retention Time
SVI	:	Sludge Volume Index
TSS	:	Total Suspended Solids
TON	:	Total Oxidised Nitrogen
VSS	:	Volatile Suspended Solids
WAS	:	Waste activated sludge

13. COMPANY CONTACT / TELEPHONE NUMBERS:

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