USBF Comparison to SBR

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1 GENERAL CONSIDERATIONS

Both the Sequencing Batch Reactor (SBR) and the Upflow Sludge Blanket Filter (USBF) are modifications of the Activated Sludge Process. The SBR was developed in the U.S. in the late 1960's and became widely used during the 1980's and 1990's. The process concepts incorporated into the patented USBF process were developed both in Europe and the U.S. in the 1970's. Various forms of the USBF process concepts including "anoxic selector zones", and "upflow blanket clarifiers" have been used worldwide for the last 25 years.

Both the SBR and USBF processes are fully capable of treating municipal wastewater to meet the U.S. and International Standards of secondary wastewater treatment, (30 mg/l BOD, 30 mg/l TSS); advanced secondary treatment, (10 mg/l BOD, 10 mg/l TSS and 1 mg/l NH_4-N) and tertiary treatment (10 mg/l BOD, 10 mg/l TSS and 10 mg/l total nitrogen) standards.

Both processes are designed using the same basic biological treatment kinetics for carbonaceous removal, nitrification and denitrification. JMS has developed and refined kinetic design models for both processes based on the approach of Lawrence and McCarty which is incorporated into U.S. Textbooks in Sanitary Engineering and in the USEPA Design Manuals for Wastewater Treatment and Nutrient Control. A complete description of the kinetic process design models and a detailed description of each process can be found elsewhere. This evaluation will present a comparison of the two processes including:

- Design loading considerations
- Performance and operating parameters
- Power requirements
- Modular design considerations and mechanical component design
- Cost factors

Each of these is discussed in the following sections

2 DESIGN LOADING

The table below presents a comparison of the major loading parameters for both processes

Parameters	USBF	SBR
F/M	0.01 to >1.0	0.01 to >1.0
MLVSS (mg/l)	4,000 - 6,000	2,000 - 4,000
Hydraulic loading (average to peak ratio)	1 to 6	1 to 4
SVI	80 - 120	250 - 350
SRT days	5 - 70	5 - 50

Both processes respond well to peak to average hydraulic loading. The USBF process addresses increased hydraulic loading by first, producing a faster settling mixed liquor due to the lower SVI, and secondly, by the unique sloping sidewall clarifier that allows the sludge blanket to rise which automatically increases the surface settling area, and by inter partical flocculation in the upflow clarifier. The SBR addresses increased hydraulic loading by adjustment of the settling cycle time.

The USBF process has been used in Europe under low F/M ratios (0.01 to 0.05) or in the "superaeration mode" to achieve very low removal of BOD and refractory COD when necessary. In the US, the F/M loadings are increased for municipal waste to the 0.1 to 0.3 range for BOD removal for municipal sewage and to over 1.0 for high rate treatment of high strength industrial waste.

Design loadings (F/M's) for the SBR system, are generally less due to the larger aeration requirements since air is only supplied during a portion of the total SBR cycle time thus increasing installed aeration HP. Because of the patented and unique Sludge Blanket Filtration Concept of the USBF and the incorporation of an "Anoxic Selector Zone", the operating Sludge Volume Index (SVI ml/g) for this process is much lower than for the SBR. This is a critical factor in the overall performance of this process.

3 PERFORMANCE AND OPERATING PARAMETERS

The table below presents the typical removal efficiency of the USBF and SBR system.

Parameters	USBF	SBR
BOD removal (mg/l)	<5	<5
Nitrification (mg/l)	<0.5	<1.0
Denitrification (mg/l)	<1.5	<1.5
TSS (mg/l)	<5.0	<10.0

Data available to support removal efficiencies, based on the state-of-the-art kinetic design concepts.

A major feature of the USBF process is the combined advantage of an anoxic zone prior to the aeration zone for "conditioning" the mixed liquor prior to the upflow solids contact flocculating clarifier. The anoxic zone reduces or eliminates filamentous sludge and provides a very low (80-120 ml/g) SVI. The anoxic zone operates in this fashion for BOD removal and BOD removal plus nitrification. For denitrification, the anoxic zone is increased in HRT, and utilizes the endogenous carbon in the wastewater as the electron donor for denitrification. In the SBR process, a separate carbon source is normally added for denitrification. The most common carbon source is methanol. Unless the methanol addition is closely controlled, over dosing can lead to the discharge of excessive BOD. The USBF process can reliably remove TSS to a slightly lower level (5 mg/l) than the SBR (10 mg/l), due to the better conditioned mixed liquor suspended solids.

4 POWER REQUIREMENTS

From a process standpoint, both the USBF and SBR require the same amount of oxygen for BOD removal and nitrification in accordance with accepted kinetic theory. Both processes take advantage of the Nitrate Oxygen returned (2/3 of oxygen required for nitrification) during denitrification.

The installed HP for the USBF process is less than for the SBR process since the SBR process must provide the same amount of oxygen in a shorter period of time i.e. during the aerated fill cycle and the aerated react cycle. The installed HP for SBR's is typically 30 to 50% higher than for the USBF process, for the same influent and effluent design conditions. The aeration efficiency of fine or course bubble aeration is also greater for USBF than for the SBR since the average aeration depth is lower for the SBR due to decanting up to 30% of the aeration tank volume thereby lowering the depth of aeration by 30%. At 30% decant, the average aeration efficiency of an SBR system would be 85% of that achieved by a USBF system.

5 MODULAR DESIGN CONSIDERATIONS AND MECHANICAL COMPONENT DESIGN

The USBF design is a continuous flow system that incorporates the aeration zone, the clarifier and the anoxic zone in a single tank. The only mechanical equipment required is the blower for aeration and air lifting return sludge (in larger plants low HP axial pump is used for sludge return). Waste sludge can be taken off the air lifted sludge return line unless prohibited by head considerations.

The SBR system is normally a two-tank design and in addition to the aeration requirements requires decanting by pumping from each tank. SBR's are also normally equipped with separate sludge wasting pumps. In order to meet mechanical reliability requirements, duplicate decant and waste sludge pumps are required for each separate SBR tank. From a mechanical standpoint, the USBF system is much simpler and requires much less rotating equipment. This provides a significant advantage to the USBF in:

- original equipment cost
- cost maintenance
- operational simplicity

For example, airlift pumps rarely fail compared to mechanical pumping systems. Although there are no size limitations on either the USBF or SBR systems, the USBF single tank design lends itself to higher capacity system design better than the SBR. Dual tank SBR systems have generally been limited to 0.5 to 1.0 mgpd (1,900 to 3,800 m^3/d) volume per tank due to the requirements for decant pumping. In standard SBR systems, the decant rate is 7 to 15 times the average design flow. Over 98% of SBR systems installed in the U.S. are under 1.0 mgpd (3,800 m^3/d). The USBF single tank systems have been installed with up to 4.0 mgpd (15,000 m^3/d) capacity.

6 COST FACTORS

The capital cost of biological treatment processes are summarized below:

- The cost of constructed tankage to provide the required Hydraulic Residence Time (HRT) to meet the process kinetic requirements. (These requirements are the same for both processes).

- Cost of clarification tankage. The cost of the mechanical support equipment, including pumps, blowers, internal piping and decanting devices.

- Site, civil works and land area requirements.

- System control equipment.

Electrical supply and equipmentThe USBF and the SBR processes require the same basic tankage for the biological processes since they are based on the same biological kinetics. The USBF is a single tank system and the SBR is a dual tank system. The mechanical requirements for the SBR system designs are much greater than for the USBF system because of the requirements for decant pumping and waste sludge pumping with duplicate units for each. Sludge Filtration tankage is incorporated into the single tank design for USBF and into the dual tank design for SBR's. The installed HP requirements for the SBR form of treatment is much greater (30 - 50%) than for the USBF as previously discussed.

The electrical requirements including total power and power distribution is a first power function of installed HP and is greater for the SBR form of treatment than for the USBF due to the greater number and spatial distribution of electrical motors in the SBR system. Both the USBF and the SBR are compact treatment systems as compared to conventional activated sludge or the oxidation ditch form of treatment. The site and civil works for these forms of treatment are much less than for conventional secondary or advanced secondary treatment. In terms of land area required, the USBF system requires approximately 60-80% of the land area of the SBR system depending on system layout.

7 SUMMARY

The following describes our summary analysis of the SBR and USBF processes.

1. Both the USBF and SBR processes have been proven in the U. S. and throughout Europe to reliably meet all current standards for BOD removal,

nitrification and denitrification standards down to an effluent BOD level of <5.0 mg/l, TSS of 5-10 mg/l, NH_4-N of 1.0 mg/l and a total nitrogen of less than 10 mg/l. (Extensive operating data are available to document the above).

2. The USBF process requires less installed HP than the SBR process.

3. The USBF process has less mechanical components than the SBR and is therefore a much simpler process.
4. The USBF process with anoxic zone treatment of mixed liquor produces an inherently more stable mixed liquor, lower operating SVI's and a slightly higher removal efficiency for TSS.

5. The USBF system is more flexible in retrofitting existing plants than the SBR because of the unique single tank upflow sludge filter concept and design of the USBF.

6. The USBF has a smaller land area requirement ("footprint") than the SBR. Both systems are much more compact than conventional activated sludge.

7. The total electrical and mechanical requirements are much less (20-40%) for the USBF than for the SBR form of treatment.

Based on total process requirements including tankage (equal), mechanical support equipment, power requirements, electrical, controls, site work and land area required, it would appear that the USBF system would have a significant cost advantage over conventional activated sludge, the oxidation ditch form of activated sludge and SBR's for treatment system sizes ranging from 1.0 to 50 mgpd (3,800 to 190,000 m^3/d).