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STARTUP OF A FULL-SCALE WASTEWATER TREATMENT PLANT AT A CHEESE PRODUCTION FACILITY

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ABSTRACT

This technology is a high-rate activated sludge process. A compact, high-pressure reactor replaces the large open aeration basin commonly found in activated sludge systems. Vigorous mixing, high oxygen transfer, and high mixed liquor concentrations are critical design limitations in many conventional plants. The system has intensive mixing, high oxygen transfer, and high MLSS in a compact subsurface reactor, making it an efficient high-rate biological system. A system was selected for treatment of high-strength wastewater from a large dairy. The plant design consists of 3.2 million liters (850,000 gallons) of equalization capacity, two 2.75 m (9 ft) diameter 94 m (308 ft) deep bioreactors, and two rectangular flotation clarifiers. Influent is cooled to retain mesophilic conditions in the system.

During startup, 4- and 24-hour composite influent and effluent samples were collected and tested for TS, COD and pH. Highly variable loading from the dairy averaged 20,430 kg BOD_5/day (45,000 lbs BOD_5/day) and the flow averaged 2,320 lpm (613 gpm). These values far exceeded the design capacity of the plant, which is rated for an average load and flow of 7,300 kg BOD_5/day (16,000 lbs BOD_5/day) and 1,840 lpm (486 gpm), respectively. Peak 4-hour loading in the plant exceeded 25,000 lbs BOD_5 – more than 5 times design. Despite BOD_5 loading 3 times design, the system achieved an average BOD_5 removal of 90%.

Despite an average oxygen transfer efficiency (OTE) in excess of 70% and a maximum OTE of 86% (conventional air activated sludge facilities achieve 8 – 10% OTE), oxygen was limited in the system due to the continuously overloaded conditions. With additional aeration capacity installed to design limits, the oxygen demand of the organic overload still exceeded the supply of oxygen. The flocculating ability and flotation of the microbes were invariably hampered –characteristics consistent with an ongoing organic overload. This plant demonstrates the process is capable of treating a high-strength wastewater with a very small footprint facility. The 1,100 square meter (12,000 ft^2) plant treated the BOD_5 load of a 300,000 population equivalent during startup. It was demonstrated that the system has lower capital costs than competing technologies, as well as low variable and total operating costs – approximately $.03 and $.05 per lb BOD_5 destroyed, respectively.

1. INTRODUCTION

This paper presents the startup performance results of a facility designed to treat high-strength wastewater from a large dairy. This is a high-rate activated sludge process. A compact, high-pressure reactor replaces the large open aeration basin commonly found in activated sludge systems. Vigorous mixing and high oxygen transfer are critical design limitations in many conventional plants. The system has both intensive mixing and high oxygen transfers in a compact subsurface reactor, making it an efficient high-rate biological system.

1.1 Key Process Features and Advantages

The effluent treatment system is a state-of-the-art high-rate aerobic activated sludge process. It uses an in-ground hyperbaric aeration reactor, a device that has been proven effective through more than 20 years of commercial operation. The reactor's patented design results in a smaller reactor volume and reduced energy consumption, giving it significant capital and operating cost advantages over conventional hyperbaric aeration systems.

The following key features give a strong advantage over all other competing biological treatment processes, including sequencing batch reactors (SBRs), conventional activated sludge processes and aeration ponds:

- It is a proven process with similar systems already operating successfully in numerous municipal and industrial applications worldwide.
- Operating costs are substantially lower, usually less than half that of conventional aeration processes.
- VOC (volatile organic compounds) emissions are minimal compared with conventional aeration processes, which can discharge up to 60% of the VOCs contained in the influent stream to atmosphere.
- The system is very compact and has a low space requirement, usually less than 20% of the space used by conventional processes.
- There are no open aeration basins; therefore, visual impact and odor emissions are minimal.
- The system can be economically enclosed in a building in locations where climatic conditions are unfavorable or if it is desirable for the plant to blend in architecturally with the surrounding environment.
- The system is uncomplicated, easy to operate and maintain, and well suited to fully automated, unattended operation;
- Concentrated waste streams with fluctuating flow rates and strengths can be treated to a high effluent quality.
- The low aeration significantly reduces foaming in applications normally prone to foaming.

- The leak-tight steel and cement grout reactor casing eliminates ground water contamination concerns experienced with conventional aeration ponds.
- The in-ground aeration reactor is much less likely to sustain damage in an earthquake than above-ground aeration ponds or reactors.

1.2 Process Applications

The process is ideal for treating biodegradable industrial wastewater streams and municipal sewage. It has particular advantages in applications with the following conditions that can make conventional processes unsuitable:

- Sites with space constraints;
- Wastewater streams with high VOC content;
- Retrofits and plant expansions;
- Applications with very concentrated wastewater streams;
- Sites with high precipitation or extreme temperatures;
- Sites close to residential areas;
- Applications with fluctuating loads;
- Locations where large unsightly plants are undesirable (i.e. recreation areas);
- Sites in areas with high seismic activity;
- Wastewater streams prone to foaming.

1.3 Reactor Features

The principal difference between this system and other technologies employing in-ground hyperbaric aeration reactors is that this reactor has been reconfigured to incorporate three separate treatment zones, giving it a significant capital and operating cost advantage over similar old-generation technologies.

- The oxidation zone is the upper portion of the reactor and includes a central concentric draft tube for mixed liquor circulation.
- The mixing zone is immediately below the oxidation zone. Air, as required for high-rate bio-oxidation within the upper zone of the reactor, is injected into the mixing zone. The injected air also provides the drive mechanism for airlift circulation.
- The polishing zone, or oxygen soak zone, occupies the bottom of the reactor.

Installed by conventional drilling or excavation techniques, the reactor is typically 75 m to 110 m (250 ft to 350 ft) deep, occupying only a fraction of the area used by conventional surface basins and using only about 10% of the air consumed by conventional aeration systems. The diameter of the reactor, nominally 0.75 m to 6 m (2.5 ft to 20 ft), is determined by the quantity and strength of the material to be treated.

Process Stages	
1	**Aeration**. Rising bubbles travel up the annulus creating a density gradient that results in airlift circulation within the oxidation zone.
2	**Influent Injection**. Untreated influent is introduced to the recirculating liquor through the influent pipe at a level above the air injection point in the mixing zone.
3	**Biodegradation**. High oxygen transfer rates due to the pressure and depth of injection insure high dissolved oxygen content and reaction rates within the oxidation zone.
4	**De-gassing**. Entrained spent off-gas bubbles are released to the atmosphere.
5	**Polishing**. High dissolved oxygen concentrations and residence times result in a high degree of residual BOD oxidation in this zone. Dissolved gas saturation is also utilized to drive solids separation by flotation in the clarification step that follows.
6	**Withdrawal**. Polished mixed liquor is forced from the shaft to the flotation clarifier by hydrostatic pressure.
7	**Flotation**. Rapid depressurization of the mixed liquor as it travels to the surface results in a well-aerated, low-density floc. The flotation clarifier produces a highly concentrated biomass and a high quality liquid effluent.

The table below is a comparison of one client's requirements and the performance data for the above system.

Element	discharge limits	Our System
BOD	5mgl	>5mgl
TSS	5mgl	>5 mgl
P	1mgl	>1ppm
N	3.9mgl	>3ppm
fecal	23	>10
Residual chlorine	.026	.02ppm