COMPARISON OF VERTAD™ TO ATAD AND ANAEROBIC DIGESTION PROCESSES

VERTAD™ Process Summary

VERTAD™ is an auto-thermophilic, aerobic digestion process, employing a subsurface vertical reactor to aerobically digest mixed primary and secondary wastewater treatment solids – or other organic waste streams, such as the waste from various food industries. High metabolic activity results in heat generation, which enables production of Class A Biosolids at short solids retention times. The Class A Biosolids produced in VERTAD™ are suitable for land application to all types of sites without restriction, as they are free of any pathogenic bacteria. The VERTAD™ process has been studied extensively at a demonstration facility in Renton, WA. The results from these studies form the basis of the following comparison discussion.

VERTAD™ versus Conventional ATAD Systems

Both VERTAD™ and ATAD systems operate on the same basic principle of aerobic, auto-thermophilic digestion. The principal difference between VERTAD™ and conventional ATAD systems, is its in-ground hyperbaric aeration reactor. The VERTAD™ reactor's patented design features give it the following advantages over conventional ATAD systems:

- The VERTAD™ system achieves an average oxygen transfer efficiency (OTE) of greater than 50%, whereas the ATAD system achieves only an average of 24%. The high oxygen transfer rates in VERTAD™ are associated with the pressure and depth at which air is introduced to the bioreactor.

- The high OTE in VERTAD™ results in enhanced digestion of the sludge and a decreased detention time to meet the Class A Biosolids requirements. The VERTAD™ system achieves 40% VS reduction in a 4-day retention time. This compares favourably to conventional ATAD systems which can require 8- to 12-day retention times for 40% VS reduction.

- In a recent comparison study of the energy requirements between VERTAD™ and ATAD processes, it was found that VERTAD™ out-performed a conventional ATAD process, operating with 31 to 45% less energy per pound of VS destroyed in the system. This is due to the fact that the air that is introduced to the bioreactor aids in several other process functions at no incremental cost. Not only does the air satisfy the primary requirement of providing the microbes with dissolved oxygen, it serves as an air lift pump – eliminating the need for mixers in the bioreactor. The air indirectly provides the dissolved gasses necessary for solids flotation in the flotation cell that follows the bioreactor – decreasing the size of the downstream dewatering equipment. All of this is achieved due to the high oxygen transfer.

- Due to the high oxygen transfer efficiency in the bioreactor, VERTAD™ needs only a fraction of the air volume that a conventional ATAD uses – $1.7m^3/hr \bullet m^3$ compared with $4.0m^3/hr \bullet m^3$, respectively. This means that significantly less off-gas is produced in the VERTAD™ process, reducing the size of biofilter required for off-gas treatment.

- The VERTAD™ system has decreased chemical requirements compared to ATAD. VERTAD™ biosolids dewater to 30% solids using a conventional centrifuge, with less than 20 lb/ton polymer addition. This significantly decreases the cost of hauling the dewatered solids to land application sites. While ATAD biosolids can also be dewatered to approximately 30% solids in a centrifuge, the polymer requirements are usually significantly higher – as high as 60 lb/ton polymer addition.

- While traditional surface tankage ATAD processes employ two or three tanks in series to achieve sufficient temperatures and prevent short-circuiting, VERTAD™ combines the stages within a single reactor, occupying a fraction of the area otherwise required.

- Except for very small flow facilities, the capital cost of a VERTAD™ system is lower than that in conventional ATAD plants of similar size. Decreased land requirements, considerably less surface tankage (less concrete), less dewatering equipment and fewer pumps are some of the key elements decreasing the capital cost.

The following table summarizes the major operating cost differences between VERTAD™ and ATAD systems.

Table 1 – Comparison of VERTAD™ and Conventional ATAD Processes

Parameter	ATAD (Design)[1]	ATAD (Case Study)[2]	VERTAD™ (Case Study)[3]
Power Usage (kWhr/ton TS fed)	442	520 – 641	315
Power Usage (kWhr/kg VS destroyed)	1.52	1.85 – 2.32	1.27
Aeration (m^3/hr•m^3 active volume)	4	Not Measured	1.7
% VS Destruction and HRT required	40% in 5-8d	40% in 12-15d	40% in 4d
Average System Oxygen Transfer Efficiency (%)	Not Reported	24%	50%

1 EPA Technology Transfer #EPA/625/10-90/007 – "Autothermal Thermophilic Aerobic Digestion of Municipal Wastewater Sludge"
2 Measurements at a full-scale, 4-ton TS/day ATAD facility.
3 VERTAD™ results from the King County demonstration facility.

VERTAD™ versus Anaerobic Digestion Systems

While VERTAD™ operates on the basis of aerobic, thermophilic digestion, anaerobic digestion systems operate in the absence of air, and are typically mesophilic. The following is a comparison between VERTAD™ and anaerobic digestion systems:

- The VERTAD™ system achieves 40% VS reduction in a 4-day retention time. This compares favourably to conventional anaerobic digestion systems which can require 25 to 30-day retention times for 55% VS reduction.

- In a recent comparison of the energy requirements between VERTAD™ and anaerobic digestion processes, it was found that the yearly operating and maintenance costs are similar in the two processes. The VERTAD™ process had lower operating costs in the areas of chemical requirements, dewatering, and biosolids hauling.

- The VERTAD™ system has decreased chemical requirements compared to anaerobic systems. While VERTAD™ biosolids dewater to 30% solids with less than 20 lb/ton polymer addition, anaerobic biosolids only dewater to 20% solids.

- Odor panel testing has indicated that the off-gas from the VERTAD™ process is generally odor-free. Character descriptors for the VERTAD™ off-gas included terms such as “compost”, “earthy”, and “vegetation”. Biofilters successfully removed greater than 99% of the off-gas odor. The fugitive off-gas from the anaerobic digesters on site was described as “sludge”, “manure”, and “H_2S was detected”. Although VERTAD™ does not generate methane gas, it does produce hot water and does not require the extensive gas handling, cleaning, and safety equipment required in the anaerobic process.

- The VERTAD™ process operates well over a range of pH conditions and temperatures. The robustness of the process allows it to operate with less operator attention than an anaerobic digestion process.

- VERTAD™ occupies only a fraction of the area that anaerobic digesters require. In general anaerobic systems are much more complex with significantly more equipment (motors, pumps, mixers, etc…) than a VERTAD™ system.

The following table summarizes the major differences between VERTAD™, ATAD, TPAD (temperature-phased anaerobic digestion), and mesophilic anaerobic digestion systems.

Table 2 – Comparison of VERTAD™ to Conventional Digestion Processes

Technology	***Class Biosolids Produced***	***VS Removal Efficiency***	***Oxygen Transfer***	***Off-gas Control (Bad Constituents)***	***Land Usage***	***Cake Solids***	***Capital Cost****	***Operating Cost****
VERTAD™	Class ‘A’ (Unrestricted Use)	> 40% (4 day HRT)	> 50%	Enclosed tankage, controlled off-gas (trace NH_3)	Low	> 30%	Low	Low
ATAD	Class ‘A’ (Unrestricted Use)	43% (16 day HRT)	20-30%	Enclosed tankage, controlled off-gas (DMS, high NH_3)	Med.	~ 25%	Med.	Medium
Temperature Phased Anaerobic Digestion	Class ‘A’ (Unrestricted Use)	65% (21-25 day HRT)	N/A	Enclosed tankage, controlled off-gas (H_2S, Methane)	High	> 20%	High	High
Anaerobic, Mesophilic	Class ‘B’ (Restricted Use)	55% (25-30 day HRT)	N/A	Enclosed tankage, controlled off-gas (H_2S, Methane)	High	> 23%	Med.	Low

*Note that the capital costs for VERTAD™ become larger if the plant size is too small. In such plants, other circumstances (like restricted land availability) would have to be present to warrant the use of this technology.

VERTAD™ in Series with Anaerobic Digestion

It should be noted that other digestion flowsheet options such as incorporating a post-VERTAD™ anaerobic digestion step have been tested and show considerable promise. The technologies appear to be complementary in that the VERTAD™ process readily degrades fats and proteins, whereas the anaerobic digesters are able to destroy cellulose. This synergy of technologies results in enhanced VS destruction – up to 70%. These results support the use of VERTAD™ as a retrofit option for facilities with anaerobic systems that are overloaded, or that wish to produce Class 'A' biosolids.

Conclusions about VERTAD™ Performance on Sewage Sludge

The following conclusions were made based on the results of the King County demonstration project:

1. The VERTAD™ reactor readily circulates thickened solids (4-6% TS); The upper zones are well mixed while the lower zone is hydraulically separate, ensuring pathogen destruction.

2. The reactor achieved greater than 40% VS reduction of sewage sludge in a 4-day SRT.

3. Oxygen transfer efficiency was greater than 50% when the reactor total solids concentration was at or below 4.5%.

4. VERTAD™ product easily float thickened to 8-12% TS by pH-shift CO_2 release; thickened product dewaters to greater than 30% cake solids with low polymer demand (14 lbs/ton).

5. Organic nitrogen and fats, oils, and greases – compounds typically responsible for objectionable odors – were preferentially degraded over organic solids comprised primarily of cellulose.

6. Mesophilic anaerobic digestion of VERTAD™ product provided overall volatile solids destruction of 67% and gas production of 0.36 L CH_4/g COD removed, with a combined solids retention time of 15 days (4-day SRT in VERTAD™ followed by an 11-day SRT in anaerobic digestion).

7. VERTAD™ has low operating cost due to low energy requirements (1.27 kW•hr/kg VS destroyed), low polymer requirements (14 lbs/ton), and low trucking/disposal costs (> 30% TS cake).

8. The VERTAD™ process has a minimal footprint requirement making it an ideal retrofit for facilities that require additional capacity, or current Class B biosolids generators that wish to produce Class A Biosolids.