States of Jersey

Liquid Waste Strategy

Technical Note on Deep Shaft ASP Reactors

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1 INTRODUCTION

This technical briefing note examines the feasibility of using DeepShaft ™ technology to replace the current secondary treatment process at Bellozanne Sewage Treatment Works. It focuses primarily on process issues and should be read in conjunction with our previous report entitled "Jersey Treatment Process Review Report" of September 2009.

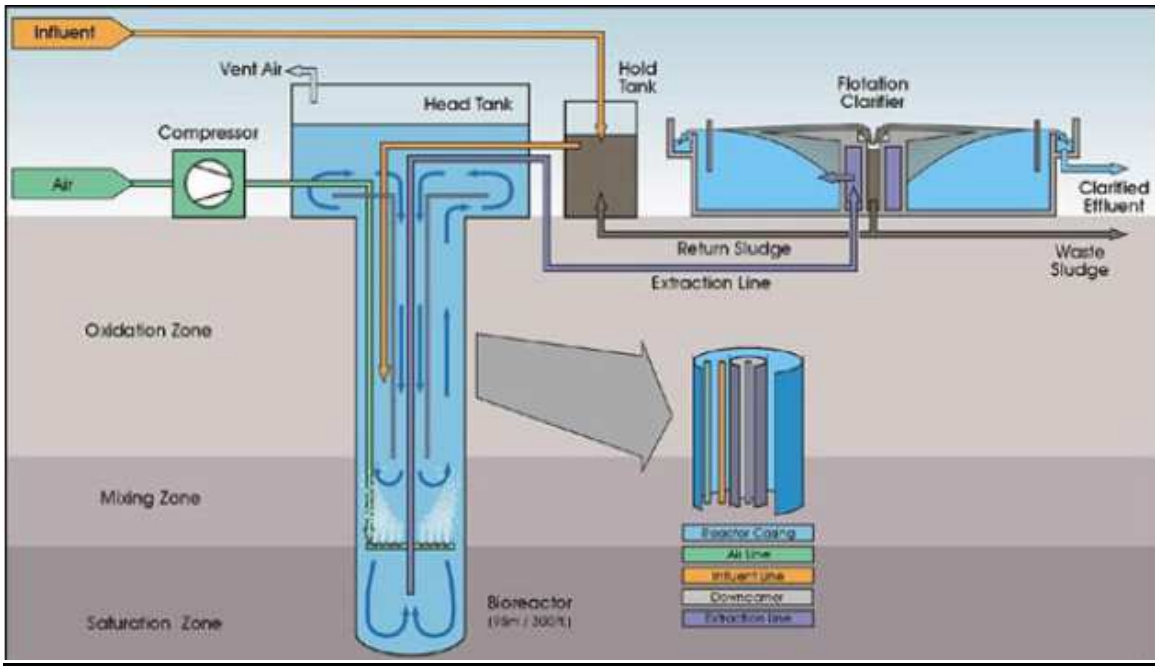
2 DEEP SHAFT ASP TREATMENT

The DeepShaft™ activated sludge system was invented by ICI as a spin-off from the manufacture of Pruteen, which is a microbial protein grown on methanol. The patent for the process is currently held by Aker Kvaerner. A brochure for the system is included in Appendix 1.

The DeepShaft™ is essentially a high rate activated sludge system which is able to run at higher mixed liquor concentrations and at loading rates 5 to 10 times greater than conventional systems. The aeration requirement is also reduced by the nature of the process because it has a greater efficiency of oxygen transfer into solution.

The DeepShaft™ system works by drilling a shaft typically 40 to 100m deep, using techniques from the oil industry. Raw sewage enters a holding tank where it is mixed with return activated sludge. This mixture of raw sewage and return activated sludge is passed down the centre of the shaft and re-circulates back up the outside with the aid of compressed air. This typically takes between 2 to 6 minutes and the sewage is circulated around 20 to 40 times prior to discharge. After treatment the effluent is clarified by flotation or sedimentation. Figure 2.1 shows a typical DeepShaft™ system.

Figure 2.1 - DeepShaft™ Activated Sludge System.



The technology is not in widespread use with only 80 works in operation world-wide and only three in the UK namely, Tilbury, Southport and Billingham. Of these, Billingham treats solely industrial flows and Tilbury has a high proportion of industrial flow. Southport was constructed due to land constraints.

There are a number of advantages of the DeepShaft™ system and the principal generic ones can be summarised as follows: -

- No primary settlement stage is required
- High energy efficiency with removal rates of 1 to 4kg/BOD Kwhr
- Higher efficiency of oxygen transfer requiring less aeration for the same function
- Process is unaffected by temperature changes
- Smaller footprint compared to conventional activated sludge
- Resistant to hydraulic or loading variations
- Less potential for filamentous growth
- Typically reduced seeding period
- Initial start-up of the activated sludge process is reduced to 3 to 4 days in comparison to approximately 18 to 20 days for conventional processes.

As would be anticipated, there would be a number of disadvantages with respect to its use at Bellozanne and these are highlighted in Table 2.1.

Table 2.1 - Disadvantages of DeepShaft™ Activated Sludge System

Disadvantages	Relevance to Bellozanne
High capital cost of drilling and lining the deep shaft, depending on the underlying geological conditions.	The more difficult the ground conditions, such as Jersey where there is rock, the greater the capital cost.
Due to the sub-surface nature of the deep shaft, it is not possible to observe the mixed liquor and thus more difficult to operate or diagnose problems.	There have been issues with the current secondary process at Bellozanne and additional operational risks are to be avoided.
The efficiencies and cost savings of the system are only realised where the influent BOD strength is greater than approximately 500mg/l	The raw sewage is domestic in nature and does not contain any high strength industrial loads
No nitrification or denitrification	A separate treatment process would be required.
The effluent normally requires de-gassing. High quantities of carbon dioxide and nitrogen can be released out of solution with the rapid reduction in pressure as the mixed liquor rises to the top of the shaft	Required
Maintenance of the high pressure blowers is more onerous than a conventional system	Refer to above comment about operational risks

3 CONCLUSIONS

The DeepShaft™ process is an alternative to activated sludge systems. To date, its principal uses in the UK have been to treat high strength industrial flows or where space for a conventional works has been insufficient. The strength of the sewage at Bellozanne is not high, which means that the operational cost savings are unlikely to materialise. Whilst the area at Bellozanne is limited, it is possible to accommodate a conventional works. The DeepShaft™ process would eliminate the need for new primary tanks but additional processes would be required to nitrify and denitrify to achieve the Total Nitrogen consent for the works.

The lack of a significant track record in the UK for this process means that there would be increased operational risks, which would be compounded given the island setting and the past problems with the current process at Bellozanne.

In view of the above, we would not recommend the use of the DeepShaft™ activated sludge system at Bellozanne.

APPENDIX 1 – DEEPSHAFT MARKETING BROCHURE

Industrial

Deep Shaft Process Technology

Deep Shaft Advanced Biological Treatment Process

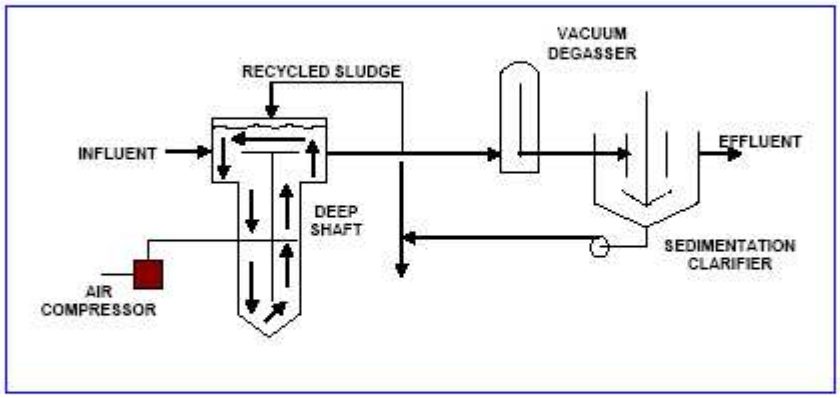
High intensity aerobic liquid effluent treatment process. With oxygen transfer rate typically 10 times higher than conventional process.

Well suited for treatment of high strengths wastes with low footprint operating and capital cost

Description

The Deep Shaft, a high intensity aerobic liquid effluent treatment process, comprises a single, vertical shaft which is divided into up-flow and down-flow sections known respectively as the riser and downcomer.

The effluent circulates rapidly in the shaft driven by the injection of compressed air which provides a differential density in the riser and downcomer. The resultant turbulent flow provides intense mixing of gas, liquid and biomass. The liquor typically takes between two and six minutes to circulate once around the shaft and head tank and on average it circulates 20 to 40 times before discharge. In this way the oxygen and the effluent flow concurrently and are maintained in contact for two to four minutes per cycle thus ensuring efficient oxygen transfer. The low ratio of the feed to the re-circulation flow means that the feed is rapidly diluted and mixed with the entire mass of activated sludge in the system, thereby ensuring maximum resistance to shock loads.



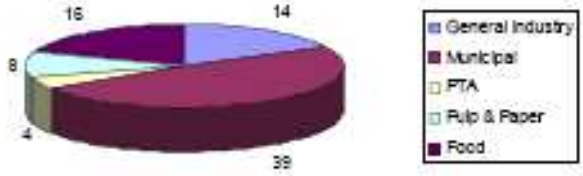
The choice of methods for separating the treated effluent from the activated sludge solids lies between sedimentation and flotation.

Industrial

Typically the shaft, is between one and eight metres in diameter and 40 to 100 metres deep. Surmounting the shaft is a gas disengagement head tank. The air serves to supply the micro-organisms with the oxygen they need for COD (Chemical Oxygen Demand) and BOD (Biological Oxygen Demand) reduction. Oxygen transfer rates are typically ten times higher than for conventional processes because of the combination of the intense mixing and the depth of the liquid in the shaft and the resultant higher dissolved oxygen concentrations.

General advantages of Deep Shaft:

- Proven technology with more than 80 plants in operation
- Mechanical simplicity.
- Low capital and operating costs.
- Low land area requirements.
- Low environmental impact (low odour, mist and noise). Also largely underground.
- High energy efficiency of 1-4Kg BOD/kWhr.
- Primary treatment not required.
- High oxygen intensity (up to 2.5 $Kg/M^3/hr$ compared to 0.1 to 0.3 for conventional processes).
- High efficiency of oxygen utilisation.
- High BOD removal rates.
- Process is unaffected by climatic changes.



Operational advantages of Deep Shaft:

- Full automation possible with minimal instrumentation.
- Resistance to changes in flowrates, BOD loadings and toxins results in robust and reliable performance.
- Capable of treating a wider range of liquor strengths (typically 1 - 30 kg BOD/m^3 day compared with 0.4 -1.3 for conventional plants).
- Can operate at higher MLSS concentration (3-10 g/l compared to 2-5 g/l) for conventional plants.
- Design sludge loading (kg BOD per day/kg of MLSS) is higher, (0.7 to 3.5 compared with 0.1 to 0.5), and this reduces reactor size.
- Limited growth of filamentous organisms means improved sludge settling and smaller clarifiers.
- Less sludge produced per kg BOD removed.
- No moving parts with low maintenance costs.
- Overall cost effective high performance.

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