Wehrle Environmental UK

Dairy Effluent Treatment Case Study: Dairy Crest, Davidstow Creamery, UK

Hybrid Wastewater Treatment Upgrade Includes MBR Technology

In this case study, Tony Robinson describes the wastewater treatment system upgrade installed at Dairy Crest's creamery at Davidstow, UK. He describes Wehrle Evironmental's approach to the design of filtration and separation technology at the Creamery to produce a flexible hybrid system incorporating a membrane bioreactor (MBR) system alongside conventional activated sludge (CAS). He shows how the various components of the existing effluent treatment system were utilised and refurbished, resulting in a system meeting requirements of the Creamery, local residents and the local environment. He describes the technology used, how it is operated and draws on Dairy Crest's operational experiences since commissioning in 2003.

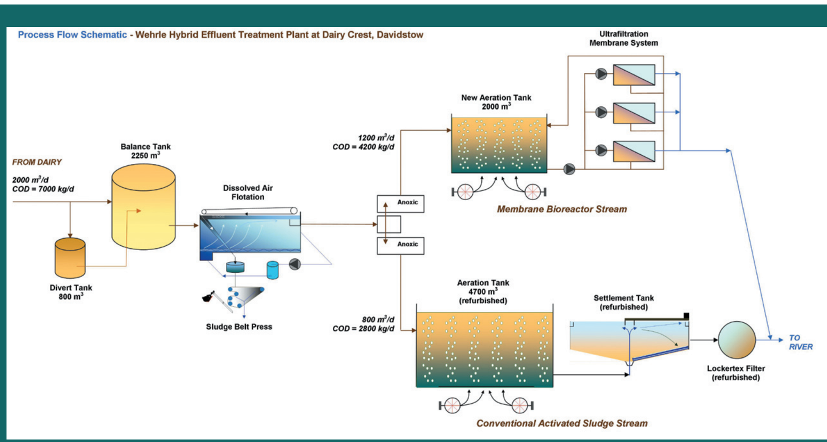


Figure 1
Creamery waste at Inlet to treatment plant and treated effluent prior to river discharge

Figure 2
Creamery waste treatment plant flow schematic

Hybrid System Upgrade

The Davidstow plant in Cornwall, UK, is the largest producer of mature cheddar in Europe and Dairy Crest's most advanced cheese making creamery. When the plant was updated with new cheese-making equipment in 2003, an upgrade to the existing effluent treatment plant (ETP) was required.

Various process solutions were presented to Dairy Crest on how to handle effluent from their new equipment and the technologies required to meet the stringent discharge quality consent for the River Inny. Most contractors proposed the construction of expensive new build wastewater treatment systems but Wehrle's creative process engineering design approach was to upgrade the existing two stream activated sludge plant on-site and add MBR technology. With over 60 industrial reference plants in successful operation across Europe, Wehrle was the first European engineering company to develop and deliver MBR systems.

Wehrle's turn-key project provided Dairy Crest with a flexible hybrid solution that would prove to be an asset during commissioning of the new cheese-making equipment when the upgraded ETP treated all wastewater up to and beyond the parameters of Wehrle's design.

The design offered operational flexibility to achieve optimum performance for each stage of the process, and utilised an efficient biological approach to treating mostly soluble chemical oxygen demand (COD) in the Creamery effluent thus avoiding the use of additional chemicals, associated labour costs and increased chemical and sludge handling requirements. Typical Creamery waste feed and treated effluent qualities are depicted in Figure 1. The upgraded plant treats an average flow of 2000 m^3/day at a COD loading that was 7000 kg/day during commissioning. Treated effluent has a biological oxygen demand of < 9 mg/l and total suspended solids of < 12 mg/l.

The existing ETP design included a two stage CAS process with high and low rate biological aeration tanks in series, each with separate settlement tanks. Clarified effluent was treated by a Lockertex screen prior to final discharge to the River Inny. Existing pre-treatment included a grease trap, a small divert tank and an aerated balance tank. The effluent flow was then treated in two anoxic tanks before entering the CAS plant. Waste activated sludge was dewatered using a belt press and then tankered away for off-site disposal.

Wehrle's design philosophy was to maintain some of the existing treatment facilities, which were functioning well, but to upgrade the key stages of the ETP and some existing equipment with limited capacity. This included refurbishment to minimise operational and environmental issues associated with noise, odour, and general appearance.

The detailed process design upgrade provided for effective pre-treatment, with improved inlet screening and larger capacity divert and balancing tanks to minimise possible shock loadings and provide a more consistent feed quality for ongoing biological treatment in the upgraded plant. A dissolved air flotation (DAF) system was installed to reduce the organic load to the biological stage, with minimal use of chemicals under normal design conditions. This was included to alleviate the existing requirement to tanker away high strength wastewater, reducing the associated traffic from the main factory.

The primary objective of Wehrle's upgrade was to increase the biological treatment capacity of the ETP. This was achieved by replacing the relatively inefficient high rate CAS process with advanced MBR separation technology which now treats approximately 60% of the wastewater flow under normal load conditions, although it is capable of treating the whole flow.

In the MBR system, no clarifiers are required as separation of the activated sludge takes place using ultrafiltration (UF) membranes rather than by using clarification. The modular system supplied is capable of being extended with additional membrane modules.

Without the constraints of conventional clarification it is possible to operate the biological process at high activated sludge concentrations, promoting better oxidation, complete nitrification and reduced biological solids

Figure 3
New equipment at Creamery waste treatment plant

Figure 4
Wehrle UF membrane system

production. The increased organic loading is treated in a relatively small tank volume, whilst providing increased sludge age (with reduced surplus sludge to dispose of) and a consistently high quality of final treated water, which is suitable for direct river discharge. MBR technology is highly efficient in terms of aeration and enhanced biological activity with less volatile organic carbons and aerosols produced thereby reducing odour emissions.

The MBR process is considered the best available technology (BAT) for the dairy industry by the UK Environment Agency (in line with integrated pollution prevention and control (IPPC) legislation in Europe - IPPC Directive 96/61/EC - 1996) and is recommended over conventional treatment technologies. In addition to the fact that UF MBR membranes have halved in cost in the last decade, advantages of MBR technology include lower surplus sludge production, smaller footprint, ease of upgrade and integrated design.

Advanced Technology

The components of the upgraded plant are depicted in Figure 2. Wastewater from the Creamery can enter the 800 m^3 Divert Tank (upgraded from the existing balance tank) if necessary before being directed to the Balance Tank, which was previously the aeration tank in the high-rate portion of the existing two stage CAS plant. With a capacity of 2250 m^3, the Balance Tank provides an equalised flow with a hydraulic retention time of over 24 hours.

Equalised effluent from the Balance Tank is pumped through the DAF process. This operates at a throughput of 105 m^3/h with minimal chemical dosing to enhance flotation under normal design conditions.

The flow is next spilt so that 40% is treated in CAS using the upgraded low-rate portion of the existing plant. Wastewater passes through an anoxic tank to before entering 4700 m^3 of capacity in the Aeration Tank, operating at a mixed liquor suspended solids (MLSS) of typically 6,000 mg/l. Activated sludge is clarified in the 17 m diameter Settlement Tank. Clarified effluent is screened through the existing Lockertex Filter before discharge to the River Inny. The upgraded CAS part of the Wehrle hybrid design currently treats an average of 800 m^3/day at a COD loading of 2800 kg/day, although it too can treat the whole flow from the Creamery.

The remainder of the equalised flow is pumped into the New Aeration Tank. This has 2000 m^3 capacity and provides the aeration component of the MBR process, operating at an elevated MLSS of 15,000 mg/l. The MBR membranes are situated in a new building along with the DAF. The New Aeration Tank and the building housing Wehrle's DAF and MBR is shown in Figure 3.

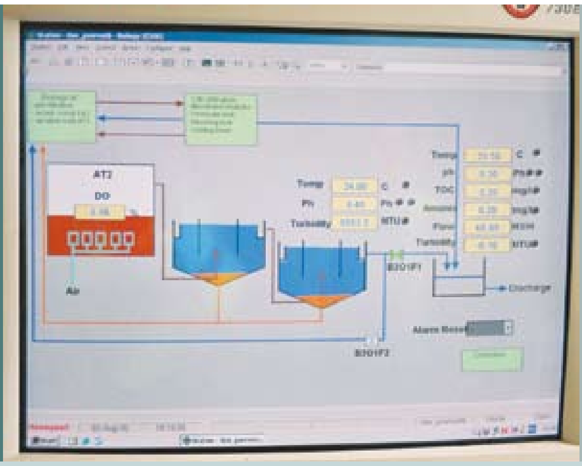
The MBR system is designed to treat a COD loading of 4200 kg/day at an average flow of 1200 m^3/day. Activated sludge from the New Aeration Tank is pumped through a header system feeding three identical membrane streams each containing tubular UF membranes housed in six modules, arranged in parallel (see Figure 4).

Cross-flow tubular membranes are used, the activated sludge being pumped along the membrane surface at high velocity, with a proportion recycled back through the feed pump and the remainder diverted back to the header system for return to the New Aeration Tank. The high flow velocity ensures adequate turbulence which minimises membrane fouling.

A proportion of the activated sludge is filtered through the membrane wall, which provides an absolute barrier to form solids-free MBR permeate. The amount of permeate produced is a function of the system pressure and activated sludge flow velocity. The MBR system typically operates at a flux rate (permeate flow rate per unit membrane area) of 100 l/m^2h, producing up to 60 m^3/h total permeate from the three streams. An additional stream can be added in the future to increase MBR capacity by 33%.

In addition to the requirement for low solids, COD and ammonia in the river discharge, the temperature has to be maintained below 30^{o}C. MBR permeate is processed through a forced-draught cooling tower to reduce temperature in summer months before being blended with effluent from the CAS stream.

Advanced monitoring instruments constantly measure temperature, pH, total organic carbon, turbidity and ammonia parameters in the treated effluent to confirm the river discharge consent is being met. The upgraded ETP is



“The system is versatile and able to treat everything from the Creamery.”

Ken Edwards, Dairy Crest

Figure 5
Screen shot of SCADA control system

automated using programmable logic control (PLC) and interfaced via the existing site Honeywell SCADA system. PLC software monitors the discharge parameters and if the effluent is out of specification, fail-safe controls are used to divert the flow back to the inlet of the ETP.

All aspects of plant monitoring and control can be accessed via the PC-based SCADA system, a typical screen-shot is shown in Figure 5. Pressures, flows and process parameters are measured at strategic points within the process and fed back to the PLC which automatically controls all aspects of normal process operation, and provides warning alarms to plant operators as required.

System Operation

By the end of 2003, Wehrle’s hybrid design had been implemented and the system was meeting the challenge of increased loading as the new cheese-making equipment at Davidstow came on-line.

Dairy Crest’s ETP plant operator, Ken Edwards, told us that the ETP had operated extremely well since commissioning and consistently met the discharge consent for the River Inny, which provides an important habitat for fish and other wildlife, and a supply of fresh water for the local salmon fishing industry. Mr Edwards said: “The system is versatile and able to treat everything from the Creamery. We now produce less than 25 m^3 of sludge per day which has significantly reduced the amount of waste we have to tanker away.”

Farid Turan, process engineer at Wehrle, has worked closely with Mr Edwards and senior management at Dairy Crest through initial discussions, installation and commissioning through to current operation of the ETP. He told us that the major factor driving the installation of the hybrid system was Dairy Crest’s ongoing commitment to minimising environmental impact. He said “The upgraded plant design has assured local residents that the environmental impact on their local community has been minimised by eliminating noise and smell issues.”

In addition to regular flushing using permeate, the membrane system can be cleaned periodically using a combination of acid and caustic solutions for removal of inorganic and organic fouling respectively. Mr Turan told us that the current cleaning regime involves just caustic cleaning every 8 to 10 weeks. This has significantly reduced operating costs which are minimised further because the DAF system currently requires minimal chemical addition to aid flotation. Membrane cleaning is carried out automatically which reduces the amount of operating man-hours required at the ETP.

Conclusions

Dairy Crest’s upgraded ETP at the Davidstow Creamery is a versatile hybrid solution able to deal with shock-loadings and produce a high quality effluent that consistently meets and exceeds Environment Agency consent requirements. The inclusion of advanced MBR technology has provided increased treatment capacity with improved ETP performance and operational flexibility. The fail-safe PLC monitoring and control logic ensures the integrity of the discharge to the River Inny is never compromised. Wehrle’s ability to engineer a process solution that meets present and future requirements has been implemented with environmental impact as the primary focus - chemical usage, sludge production, noise levels and odour emissions have all been minimised as far as possible.

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