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Melbourne Water pumps up environmental efforts

Solutions

A new control philosophy for activated sludge process comprised

- Six intelligent motor control centres incorporating
  - Allen-Bradley ControlLogix
  - CompactBlock I/O with DeviceLogix
  - 1336 variable speed drives
  - Redundant DeviceNet networks
  - PanelView 550 HMI
  - Allen-Bradley Powermonitor
- MCCs connected via dual-redundant EtherNet/IP on fibre
- ControlLogix gateway to provide connectivity to plant-wide SCADA

Control system controls and monitors all aspects of the activated sludge plant

- Multiple pumping stations and recycle flows
- Oxygen levels
- Duty cycle for aeration blowers
- Flow meters and level sensors

Results

The Rockwell Automation control system permits

- Fully automated plant (unmanned)
- Local manual control (for redundancy)
- Reduced programming and commissioning time
- Ongoing benefits for maintenance and diagnostics

New sewage treatment processes improve final effluent quality—with Rockwell Automation's Integrated Architecture playing a key role in control of the facility.

The majority of the world's population gives little thought to the massive infrastructure required to process raw sewage into an effluent suitable for ocean discharge or water recycling. For Melbourne Water's Western Treatment Plant at Werribee, adoption of an 'Environment Improvement Plan' has meant greater focus than normal.

When a 1990's environmental study revealed the prudence of reducing nitrogen loads into Victoria's Port Phillip Bay, Melbourne Water started progressively upgrading the sewage treatment processes at the 11,000-hectare Western Treatment Plant. The main goal was to improve nitrogen removal from the treated effluent, most of which is discharged into the bay. The resulting project has involved the transformation of two existing lagoon systems into 'enhanced lagoons' and the cessation of traditional land filtration methods. Just a year after the second upgraded lagoon system—known as 25 West (25W)—was commissioned, the annual amount of nitrogen discharged has been reduced by the targeted 1000 tonnes.

Development of the enhanced lagoons has been no small feat. Traditional lagoon treatment involves the gravitational flow of sewage through a series of shallow ponds, during which a natural progression of ultraviolet (UV), microbiological and biological treatment processes break down organic waste

Six distributed outdoor motor control centres, linked by a dual-redundant EtherNet/IP fibre optic communications backbone, control different sections of the activated sludge plant.

and other micro-organisms. This system is still in place; however, in order to 'beef up' the nitrogen-removal capability, an 'activated sludge process' has been added to the front end of the 55 East (55E) and 25W lagoon systems. The activated sludge process involves pumping the sewage between a series of oxygenated and deoxygenated zones loaded with bacteria to speed up natural processes.

After the successful 2001 upgrade of 55E, Melbourne Water identified a number of areas in which the plant could be further improved at 25W. One was the introduction of large blowers to provide diffused oxygen into the process, instead of surface mechanical aerators. Another advance was the incorporation of a different control philosophy. This utilised the latest distributed process and Intelligent Motor Control technology from Rockwell Automation's Integrated Architecture suite.

Sewage and Sludge

Melbourne Water's Trevor Gulovsen, a process engineer at Western Treatment Plant, explains that the first stage of sewage treatment is the anaerobic area, also known as Pond 1, where 60 percent of the pollutant load is removed in the form of gases such as methane, carbon dioxide and hydrogen sulphide. "From here it gets pumped at a rate of around 180 ML per day to the activated sludge plant, where the nitrogen content is reduced from about 60 mg to 15 mg per litre," he says.

Upon entering the main activated sludge plant basin, the sewage is mixed with brown 'return activated sludge' (RAS) from the end of the process. This provides the bacteria for the treatment, which begins in the deoxidised anoxic zone. From here, the sewage moves into the adjoining aerobic zone, where oxygen is added via submerged diffusers to promote the conversion of ammonia to nitrates. In order to transform the nitrates into atmospheric nitrogen, sewage from the aerobic zone is pumped at high volumes back into the anoxic zone, where this reaction takes place.

"The recycle rate is three to four times the inflow rate, which means that there is about 900 to 1080 ML per day flowing around the basin at any time," says Gulovsen. The third zone of the 25W activated sludge plant comprises five gravity-fed clarifying tanks. Here, the bacteria settles to the bottom to be recycled into the front of the process as the RAS, and the clear effluent at the top overflows into Pond 2 to make its way through the original lagoon system.

The Rockwell Automation control system at 25W ensures the entire process operates effectively and automatically. "The most critical part of the process is the oxygenation zone," says Gulvosen. "The bacteria will die if the dissolved oxygen levels are wrong, so the levels are measured via direct oxygen probes. Based on this, the control system will allocate the duty cycle for the blowers. There are five control zones with different air distribution along the length of the basin."

The automation system also monitors a myriad of flow meters and level sensors located throughout the plant. The flow measurements are integral to the variable speed control of the various pumping stations, which direct sewage from stage

to stage, along with the various recycle flows. These flows are all balanced by the control system to ensure the optimum flow throughout the plant.

Split the Code

The Melbourne division of systems engineering group, SEMF (formerly known as Austek), worked closely with Rockwell Automation and Melbourne Water to deliver the control solution for the 25W activated sludge plant. This was based on a conceptual design by Sinclair Knight Merz, founded on Rockwell Automation's powerful hybrid controller, Allen-Bradley ControlLogix, along with Allen-Bradley DeviceLogix to provide Intelligent Motor Control. The design also included dual-redundant EtherNet/IP communications on optical fibre and redundant DeviceNet fieldbus networks.

James Manners, SEMF mechatronics engineer, explains that the dual-redundant, industrially hardened EtherNet/IP communications backbone connects a series of six motor control centres (MCCs) located outdoors around the extensive plant. These take responsibility for controlling different sections of the activated sludge plant: diffused aeration system including three 750-kW blowers, mixers (to ensure there is sufficient turbulence in the basin to keep the bacteria suspended) and the various pump stations. Each MCC incorporates at least one ControlLogix and a redundant DeviceNet network to connect a local Allen-Bradley PanelView 550 human-machine interface (HMI), local Allen-Bradley Powermonitor and CompactBlock I/O.

To provide local manual motor control, independent of the control system, the unique Allen-Bradley DeviceLogix was utilised. "A small DeviceLogix program is downloaded into each CompactBlock I/O, which has a mini processor inside," Manners says. "Each CompactBlock I/O is paired with either a variable speed drive (VSD) or the electronic overload relay in a direct on-line (DOL) motor starter—as well as hard-wired analog process instrumentation.

"During normal operation," Manners continues, "ControlLogix sends commands to and receives information from each drive and motor starter via the DeviceLogix program. In this case, the DeviceLogix program holds the drive interlock and safety functions that would traditionally have been implemented in the PLC and duplicated in hard wiring for redundancy. If communications to the PLC are lost, for any reason, the DeviceLogix program continues to execute, maintaining full manual drive functionality."

According to David Ellis, process control and instrumentation specialist with Melbourne Water, this manual control functionality is an essential feature for a critical public infrastructure plant. "Manual control is important for redundancy," he says. "If the PLC fails, we can still put the drive into 'run' via the CompactBlock. It has also simplified the number of components in the motor starter, as we've eliminated a heap of relays that used to provide the redundancy function."

Not only is ControlLogix adept at handling the sequential control aspects of the plant, its hybrid nature makes it also ideal for the essential process control parameters—such as dissolved oxygen levels and numerous flow and level loops. "When it came to this project," says Ellis, "we investigated ControlLogix and talked with others who were very happy with the equipment. It has proven itself a robust system, and we were happy to adopt the technology."

Ethernet on Fibre

Master control of the 25W plant is provided by a central ControlLogix and PanelView 1400 HMI located in a small control building near to Pond 1. Also located here is technology provided by Rockwell Automation Encompass Partner, Hirschmann, to ensure integrity of the dual-redundant EtherNet/IP communications network, which is established in a 'hiper-ring' configuration.

"The Hirschmann ring-manager switch sends out a signal in one direction, and so long as it returns on the other side, the switch creates an artificial break in the network," says SEMF's Manners. "However, if a break in Ethernet communications is detected, the ring manager removes the barrier and restores the connection." The EtherNet/IP network between the control building and the various MCCs is provided on two optical fibre cables, buried metres apart. Similarly, each ControlLogix includes two Ethernet cards to integrate it with the dual networks.

Ellis says that Melbourne Water has adopted the dual-redundant Hirschman hiper-ring arrangement across the whole Western Treatment Plant. Individual EtherNet/IP hiper-ring architectures have been deployed at 55E and various other pump stations and new plants around the site. These are now linked via a central ControlLogix gateway, also located in the control building.

Trevor Gulovsen, Melbourne Water senior process engineer, inspects the HMI inside one of the motor control centre shelters.

Intelligent motor control from Rockwell Automation is a critical redundancy feature permitting full manual operation of the pumps.

The ControlLogix gateway allows seamless connectivity between different sections of the facility, plus it provides a direct connection to the site-wide SCADA system located in the main site operations centre at one end of the vast Western Treatment Plant site. This SCADA terminal is Western Treatment Plant's link to the outside world, and Melbourne Water's numerous other plants and pumping stations around the city.

Child's Play

SEMF first became involved in the 25W upgrade project in early 2003, after successfully completing the similar 55E project using Rockwell Automation technology. "We began development work on the software and bench-testing for 25W in about August 2003," says Manners.

Manners explains that a modular approach was adopted for development of both the hardware and software. "This means, for example, that the starter for every pump in a pump station has identical code, identical wiring and identical configuration," he says. "Duplication was child's play, as it was possible to replicate the starter to any number of other drives in the MCC, where there might be as many as 10 pumps. It also meant that we only had to debug one module of code, instead of 10. In the end, commissioning only took four months, and the MCCs were fully commissioned inside two days."

This modular approach, enabled by Rockwell Automation's RSLogix 5000 programming software, not only reduced programming and commissioning time but also provides ongoing benefits for maintenance and diagnostics. In addition, it has allowed SEMF to extend the control system philosophy to subsequent projects carried out at the site—namely, the recently completed biogas regeneration and water recycling plants.

Both are also important elements of the Environment Improvement Plan. The biogas plant converts the emitted gases from the anaerobic stage into electricity, while the water recycling plant further treats the high-quality effluent from 25W and 55E to make it suitable for irrigation.

The new 25W activated sludge plant was commissioned in September, 2004. Both 25W and 55E now have capacities of 180 ML per day (increased from 100 ML per day). This means that the old land and grass filtration systems, which originally treated around 30 percent of the 500 ML of sewage received per day at Western Treatment Plant, could be decommissioned and transformed into irrigated pasture. Moreover, Melbourne Water has met its targeted nitrogen load of 3100 tonnes per year into Port Phillip Bay.

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