Wet

As industry anticipates yet more environmental legislation, plant engineers in the water sector are developing smart engineered solutions in the face of ageing plant and increasing demand. Brian Tinham reports

With the likely passing of the European Environmental Liability Directive 2004/35/EC into British law in December – extending the existing 'polluter pays' principle to water sources, inhabited land, and protected species and habitats – industry is going to have to clean up its act, or face big bills for damage. So says Defra (the Department for Environment, Food and Rural Affairs).

Peter Castle, marketing director at insurance broker Smart & Cook, explains that included within the scope of the new legislation are toxic leaks and spills. "Anyone responsible for [these] or similar incidents will have to take immediate steps to contain the situation and notify the relevant authorities. The polluter will then be liable for the cost of decontaminating the affected areas and, in severe cases, where damage cannot be undone, polluters may have to pay to enhance another site."

All of which should serve as a wake-up call to worry those many organisations thought to be turning a blind eye to under-spending on plant (and its maintenance), installed to prevent the most common pollution – illegal waste in our waterways. For plant engineers, however – and particularly those in the water industry itself, who have to deal with the consequences of dodgy discharges – the new directive may come as welcome news.

Stories abound of engineers on water treatment plants having to deal with nightmare situations of industrial waste influents from unknown sources that threaten to push them over discharge consents, risking significant fines and potential shutdown by the Environment Agency. It isn't pretty. That said, though, existing legislation, corporate responsibility, and good engineering experience and practice in the sector have led to useful solutions, some of which could serve the rest of industry very well.

Barry Sherwood, process controller at United Utilities' Macclesfield wastewater plant, provides an excellent example. "Like many treatment plants, we have to deal with variable ammonia levels. But, back in April last year, the plant exceeded its discharge quality consent, because of illegal effluent dumped to one of our sewer inlets. At the time, Hach Lange was looking to trial some ammonia probes, capable of sending alarms as text messages to mobiles. So we took one to see if it could help us to react more quickly to the events we were witnessing."

These are smart sensors: you're looking at

More media filtration

Technology that is claimed to bridge the divide between conventional water filter systems and advanced membrane technology, and at a fraction of the cost, means any plant should now be able to control energy and environmental loading better.

So says Steve Cupples, managing director of water filtration specialist Industrial Purification Systems, of its CrossFlow MF1.0 equipment. "Most water sources show contamination above 20 micron. However, particulates are consistently higher at less than 20 micron, much of which is biological. Significantly, this is even more pronounced below 10 micron, which is the cut-off point for mainstream filtration technologies – and is the key reason why organisations can lose 30% in energy performance on heating, ventilating and air conditioning systems."

Cupples argues that better filtration technology would go a long way to enabling industry to re-use process water for secondary or even primary applications – thus saving on potable water resources. "Such a strategy can yield a significant return on investment when you take into account the cost to purchase and dispose of water in many applications," he says.

Hence the importance of CrossFlow MF1.0 filtration, with its self-cleaning technology, which filters below 1.0 micron – even down to 0.45 micron for cleaner process water – and promises reduced water treatment chemicals and electricity bills.

"Operationally, the filter system utilises a patented vortex bed stabiliser that maintains flat bed filtration with high surface turbulence," explains Cupples. "This ensures that no bio-fouling can be seeded, while holding filtered contamination in suspension above the media bed. It gives lower pressure drops, longer filtration and shorter backwash cycles, making direct savings on operational costs."

Compared with conventional media filtration, the inlet configuration allows for high flow rates – up to five times higher – while backwash volume and times are significantly lower. Also, removal rate is better than 86% at 1.0 micron in one pass, compared with the multiple passes by conventional filters – meaning less loading and fewer process stops.

devices designed to provide rapid trends of ammonium levels to control nitrification in aeration tanks and wastewater lanes (by diverting flows, dilution or chemical dosing), with a built-in differential pH electrode for stability, as well as temperature compensation and a potassium ion-selective electrode to handle interference.

At first, the probe was installed about 50 metres downstream from the plant inlet, but, after a couple of months, United installed another four – to improve its understanding of ammonia levels and control requirements throughout the plant. Each was connected to a controller, fitted with a SIM card, and the inlet alarm was set at 45mg/l, the outlet at 1mg/l and the process probes at 25 mg/l.

Sherwood reports that, initially, he received around 40 text messages every night while the offending industrial site was tracked down, but now it's just one or two per day. Which is invaluable, he says: "We're bound to get some variations, so the alerts mean that if, for example, the outfall after our BAFF [biological aerated flooded filter] plant reaches 1mg/l, now I have time to come to site, do some tests and rectify the situation."

His only gripe: currently, although ammonia trend data is available over the Internet, it's on slow dial-up. However, Hach Lange assures us that broadband will soon be available, for use with any device. Either way, Sherwood believes that, such has been the success, almost all United Utilities wastewater treatment plant will soon follow suit.

Next-generation automation

But it's not just about ammonia: the Macclesfield site is big, capable of handling 61.4 million litres per day of industrial and domestic waste from hundreds of miles of pipes and drains. So it's got big plant to match. We're talking about four screens on the inlet (two process, two storm) – with automated cleaning cycles controlled using foaming-resistant Milltronics ultrasonic level sensors before and after – as well as big automatic Dorr Oliver detriter and grit collector plant, before the treatment works itself.

Then the influent is split 60/40, with the north side taking the larger flow via two primary settlement tanks to an activated sludge plant (six aerators) and on to four clarifiers before passing through 20 biological filters. Meanwhile, flow to the south plant runs into five primary tanks, each with three submersible desludging pumps, before reaching 16 biological filters designed to extract ammonia and BOD (biological oxygen demand). Then, both flows come together and run to eight final settlement tanks, followed by the tertiary five-reactor BAFF plant. And there's sludge treatment, with gravity belt thickeners and a dual-digester enzymic hydroliser plant.

Sherwood says that almost all plant is automated, mostly under independent PLC control, and that there are few problems. He does, however, indicate that the movement to reduce energy consumption and emissions has resulted in tighter, essentially condition-based, controls in some areas – for example on the aerators. "These used to run for half an hour, every hour, with one dissolved oxygen sensor at the inlet and outlet. Now there are six probes – one for each aerator – so each can run independently. The motors are rated at 17.5kW, so they're quite big and switching them off more intelligently could save around £10,000 per year."

Meanwhile, the hydroliser process, which was

Pointers

- Chemical sensors are increasingly smart, with auto-compensation and text alerts
- Existing motor and gear systems can readily be transformed
- Utilities are moving to sensors per plant unit for energy saving
- CHP plants with net generation, using biogases, are more common
- Planned and predictive maintenance are increasingly on electronic Toughbook systems
- Remote motor monitoring looks promising for critical pumps
- Digital fieldbus instrumentation and controls make a difference

engineering

Installation of an innovative mixing system, as part of a refurbishment project at a Severn Trent's Strongford sewage treatment works, near Stoke-on-Trent, has resulted in a significant reduction in rag wrapping problems on submersible mixers and their locating shafts – which had been causing expensive outages and maintenance, using an 80 ton crane. Huntingdon-based solids mixing specialist System Mix (the mixing system design and supply part of P&M Pumps) was responsible for the new mixing system design, on the activated sludge plant's 12 anoxic zones, each 22 metres long, nine metres wide and three metres deep, specifically combining completely mixed and plug flow systems.

Existing plant, novel solutions

One of the biggest drivers for change in the water industry today is energy and Jon Snaith, general manager of planetary gearboxes specialist Brevini UK, believes there is huge potential to transform existing plant – and certainly not just by retrofitting Eff1 electric motors. "Mostly, we're asked to investigate problems, and then build engineered solutions to refurbish or upgrade plant, using modern motors and planetary gearboxes."

He gives examples at both ends of the spectrum, first citing Sanderson Heliocentric gearboxes, now obsolete, but still in use, mostly on fixed bridge scrapers around the UK. "For Thames Water, for instance, we provided a retrofit solution, using an off-the-shelf Brevini planetary gearbox that bolts on to the existing mountings," says Snaith.

Equally, on the upgrade side, he explains that, because projects usually involve replacing equipment manufactured in the '70s or '80s, the company is routinely able to cut energy costs and improve usable power output from existing motors, while also enabling existing plant to cope with greater throughputs – which is hugely useful as plant demands increase.

Snaith mentions Anglian Water, which recently reported saving significant energy by replacing screw pump gearboxes at its Maldon, Essex sewage treatment works, with planetary gearboxes and Eff1 motors from Brevini and Brammer. Brevini specified the gearbox, and designed a mounting bracket and output shaft, as well as a backstop to prevent the screw reversing when it stops. "Anglian says the new gearbox is 16% more efficient, pulling 13.4 amps, instead of the previous 16.6, and equating to a 2.1kW reduction in running power."

Then again, he points to United Utilities. "On one of their sites with four huge thickener tanks, all centrally driven, there had been six gearbox failures in less than three years. It wasn't old equipment and it wasn't cheap either. So we went back to first principles and proved that the whole drivetrain for the stirring mechanism, apart from the slew bearing, was no longer capable of handling demand. We proved they needed one and a half times the torque originally calculated."

And he tells a similar story of Yorkshire Water's 1980s-constructed Rawcliffe sewage treatment plant, with two lines of five aerators that had never previously all worked together. "When we investigated, we found broken and out-of-balance paddles, and drives that just couldn't cope with the thrust load on their taper roller bearings. We replaced the whole drive assembly and designed a revolutionary height adjustment plate, integral with the gearbox casing. As a result, to date there hasn't been a single hour of downtime."

Above: aerator controls at Yorkshire Water's Rawcliffe water treatment works

developed by United Utilities, involves a hot water system heating five tanks in sequence, using a loop with two Wellman Robey steam-raising boilers that are, in turn, part of a CHP (combined heat and power) arrangement, coupled to two 190kW reciprocating engines, driving a turbogenerator. Water temperature is 70°C and the process is maintained at 42°C via heat exchanger circuits, with boiler firing mostly driven by 60–65% methane extracted from the plant's biogas by-products, although oil-firing can be used, if necessary. Interestingly, that's now a net generator to the gird.

So much for Macclesfield's operations: when it comes to plant maintenance, Wessex Water's Jonathan Little (electrical, mechanical and instrumentation engineering manager) suggests that most forward-looking utilities are working hard to improve planned and predictive maintenance.

"Our technicians already do that – measuring flows and vibrations, checking overload settings, pump performance and so on – but managing it has been paper-based," he explains. "We're now half way through developing a new work management system, based on Hansen 8 software, that will, for example, allow technicians to see historical data, such as previous interventions, on their Toughbooks [rugged laptops]. That means they'll be better able to identify faults and take action faster. It will also show them what spares they need and where they are. It's all about improving our efficiency."

But that's not all: the company is also working to improve its remote monitoring, particularly of critical pumps. "About four months ago, we started trialling Artesis motor condition monitoring equipment on two borehole pumps and four re-lift pumps in the Yeovil area. The first two use variable speed drives; the rest are on soft starts," says Little.

The Artesis units are intelligent devices that focus on three-phase motors and their driven systems – detecting problems, such as imbalances on associated plant, misalignment, bearing failures etc. Little makes the point that installation and setup are simple – with just a couple of current transformers on the motor tails, linked to a control panel module – which makes them particularly attractive.

Preventing downtime

Operationally, he explains that it's all about avoiding problems of, for example, undetected vibration on split case motors, resulting in excessive movement in the couplings, leading to wear on the pump and drive end bearings. "These couplings are under covers, so you wouldn't see problems, unless you stripped the lot down – yet some of our older pumps are on long lead times, so we need to identify problems early. If Artesis means we can see plant dropping off, we can act faster."

Little says the company is also developing in-house systems to monitor and compare SCADA (supervisory control and data acquisition) data points on, for example, critical flows – looking for drops down the pump performance curve.

Sounds futuristic? Not at all: the petrochemical industry has been doing similar work for years and reaping the rewards. Indeed, Wessex Water is also using other technologies pioneered in that sector – notably on its Maundown water treatment plant refit, near Wiveliscombe in Somerset. There, it's investing £25 million to upgrade a 1960s plant – and virtually all new instrumentation and control is digital, connected using a Profibus DP fieldbus network.

Why? "Because of the plant diagnostics that intelligent equipment provides," says Little. "For example, on Rotork valve actuators, we can see the torque to open and close valves, and set thresholds for maintenance jobs." And it's the same for motors, drives, sample pumps and so on. Little doesn't say fieldbus kit is a magic bullet: for him, however, it should be part of all plant engineers' toolboxes – if they're serious about the environment. PE