Pump Centre

PUMP ACTION

THE OFFICIAL NEWSLETTER OF THE PUMP CENTRE

SUMMER 2016

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Editor's Column

Dear Reader

Pump Centre Conference & Exhibition

Unbelievably the Pump Centre Conference is over for another year! It was a long time in the planning, but the event itself goes by like a flash. The general consensus seems to be that 2016 was the best conference so far. The exhibition was our biggest ever, with over 100 exhibition stands, an exhibition floor space of more than 5000sqm and a 25% increase in the visitor numbers.

Switching the exhibition to the combined Halls 1 and 2 at the Telford International Centre was a very positive step and it made the event feel huge. The feedback from both the exhibitors and visitors has been very positive and we are already looking forward to 2017. Next year's conference is being held on Thursday 11th May with the conference dinner taking place on the evening of Wednesday 10th May. Please put these dates into your calendars so you don't forget!

See pages 14 to 17 - for more details about the Pump Centre Conference & Exhibition 2016.

Derek Jackson

Earlier in the year we had some very sad news that Derek Jackson former Managing Director of Hidrostal UK Ltd had passed away. Derek was an active supporter of the Pump Centre who had been on the Members Council for over a decade and was one of only three people, since its launch almost 25 years ago, to be awarded an Honorary Membership of the Pump Centre.

Derek who lost his battle with cancer in February will be remembered by the Pump Centre in two ways. Firstly, in 2017 the charity raffle at the Pump Centre conference dinner will be held on behalf of the *"Sue Ryder – incredible hospice & neurological care"* charity - the charity chosen by Audrey Jackson, Derek's wife.

The second and more permanent reminder is the setting up of an award in Derek's name. The Derek Jackson Award will be presented at the Pump Centre Conference Dinner as part of the Pump Centre's Young Engineer awards. The award will be a commendation presented to one of the short-listed Young Engineers, who in the judge's opinion, has already shown an outstanding contribution to engineering. The recipient may or may not be the overall winner of the Pump Centre Young Engineer. Hopefully the award is a fitting way to represent Derek's enthusiasm for pumps and engineering. See page 15 for more details.

Pump Centre Awards

The annual Pump Centre awards were held at the Pump Centre Conference Dinner on the evening of 11th May 2016. My congratulations go to this year's winners:

- **Young Engineer of the Year – Professional Category:**
  Winner: James Ballard (Severn Trent Water)
- **Young Engineer of the Year – Apprentice Category:**
  Joint Winner: Tim Battersby (Reid Lifting)
  Joint Winner: Scott Proverbs (WES Ltd)
- **Derek Jackson Award:**
  Charlie Lake (Wessex Water)
- **Pump Project of the Year:**
  Riventa Ltd & Deritend Ltd collaboration for Severn Trent Water.

All the judges commented on the high quality of all the participants and thanked all those who took the time and effort to enter. The launch of nominations for next year's awards will begin shortly.

John Howarth

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Sweet taste of success

Incorporated in 1990, and headquartered in Bath, England, Northavon M&E is a premium provider of end to end MEICA solutions to the water and utilities sectors throughout England and Wales.

The company has an excellent Health, Safety and Environmental track record and was recognised by the London Stock Exchange in 2015 as one of *"1000 Businesses to Inspire Britain"*.

Utilising the latest BIM (Building Information Modelling) principles and technologies together with the complementing Offsite Build techniques, we are able to significantly reduce design and on-site build times and promote maximum collaboration between all stakeholders.

From designers, end users, planners, Environmental and Health & Safety professionals and those responsible for construction, all are able to contribute to and quickly agree solutions which meet their diverse needs.

An iterative virtual design process enables all aspects of constructability, efficacy, safe maintenance and operation to be trialled, proven and approved before construction starts. The benefits of BIM are compelling and deliver not only superior solutions, but faster and, crucially, with reduced whole life costs compared with traditional methods.

Works are undertaken by our full time workforce whose skill base encompasses all aspects of MEICA delivery from initial scoping, estimating, design and build through to testing and commissioning. The workforce is spread across a number of locations and importantly the M4 / M5 corridors. In addition to the company's central offices near Bath, regional offices in Devon / Cornwall and the South East ensure effective coverage of these areas and client engagement.

We undertake a diverse range of work types from small pumping station builds / upgrades to major multi-million pound treatment works schemes.

2016 marks an important milestone for Northavon M&E Limited within the Nuclear Power arena and considerable investment has been made in the personnel, skills and credentials necessary to enter this demanding but nevertheless exciting area of business development.

www.northavonme.co.uk

Northavon M & E
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Bloodhound Ambassador scoops Young Engineer Award

REID lifting are proud to become a member of Pump Centre. With membership at a record high, exhibiting at the Pump Centre Conference was extremely beneficial to the business. The conference is recognised as the leading event of its kind within the UK and it provides the ideal platform for members to exhibit their products and services. It became apparent that showing off some of our cutting-edge lifting equipment at the event would be an ideal opportunity to broaden our audience further.

We were able to present our newest product, the PORTA-DAVIT QUANTUM. This is a unique, rapidly deployable jib crane capable of safely lifting up to 600kg. Weighing from just 18.5kg and with an integrated carry-handle, the PORTA-DAVIT QUANTUM is easily transported and particularly suited for safely lifting heavy submersible pumps.

Not only were we able to show the PORTA-DAVIT QUANTUM, but also the innovative PORTA-GANTRY RAPIDE; the easy to transport, mobile lifting gantry.

REID lifting were also invited to attend the Pump Centre Awards Ceremony after one of our promising engineers, Tim Battersby, won Young Engineer of the Year. Tim fought off some stiff competition for the highly commended accolade having grown up around innovation, *"I wanted to be an engineer from a fairly early age,"* remembers Tim, *"It's always been within me."*

Tim goes on to say that *"the award was great recognition not just for the work I had put in, but also for the whole company's efforts."* This acknowledgement was just one of the many benefits received by becoming a member and exhibiting for the first time. Many visitors became interested in our products, the work we undertake and the features that set us apart from competitors.

Some of the engineering that Tim has been involved with caught the eye of the judges, most noticeably the work REID Lifting has undertaken with The Bloodhound Project. *"It's the 1000mph attempt. REID Lifting has been involved in designing a gantry to lift the jet engine (in and) out of the car,"* Tim explains. During construction of the super-sonic car, Bloodhound chose to use a REID Lifting PORTA-GANTRY. The tall gantry lifting system helped Bloodhound to carefully construct each element of the car, powered by both a jet engine and rocket.

In addition, REID engineers are working closely with Bloodhound to create a 3,000kg WLL custom lifting solution necessary for when the super-sonic car makes its first record attempt in South Africa next year.

However, the real driver behind the project is the aim to inspire future generations to take up careers in Science, Technology, Engineering and Mathematics (STEM). With this in mind, REID are also involved in the Bloodhound SSC STEM Ambassador Programme.

In this scheme, REID Lifting will be sending Tim and Design Engineer, Luke Rossiter to schools throughout South Wales and the South West of England as official Bloodhound Ambassadors. They will be sharing their passion for the project with the aim to inspire students to get involved in science, technology, engineering and mathematics.

www.reidlifting.com

Oerlikon Metco Coatings

The Metco group of companies is part of The Surface Solutions Segment; employing in excess of 15,000 employees with an extensive network of 110 coating shops worldwide and significant R&D capabilities, combined with significant coating material and equipment manufacturing capacity.

The UK site, located near Manchester, with its 40 strong team, has successfully provided thermal spray coatings for industrial applications for nearly 25 years and its continued success, built on quality, service and technical expertise has led to the current £1.2M relocation project to larger, more modern premises to facilitate further growth within a variety of sectors including oil and gas, chemical, power generation and wastewater.

In addition to the coating capabilities the UK operation has extensive grinding and polishing capabilities together with some machining capabilities. The Dukinfield facility has a strong market understanding of pumps and associated equipment.

www.oerlikon.com/metco


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Let's Solve Water

The Revolution Begins

In 1947 Flygt, a Xylem brand, revolutionised industry with the launch of the world's first electric submersible drainage pump, followed a few years later by the first submersible wastewater pump in 1956. Both developed by Flygt, the products brought about a revolution for the industry – saving customer's space and build costs and was also less visually intrusive for those living near to them.

Over the decades that followed, Flygt has continued to lead the way in wastewater pumping solutions. In 1987 for example, Flygt launched the banana blade mixer – a large slow moving back-swept propeller providing clog-free operation and high efficiency. Then in 1997, the N-pump series was launched to market, featuring an insert ring and hard iron impeller, followed by the Adaptive N-impeller in 2009, bringing a step change in clog resistance and reduction to unplanned maintenance.

With a heritage deep-rooted in innovation, Flygt continues to make further improvements and advancements to technology – all of which have helped make it the leading brand in wastewater pumping.

Xylem is one of only a few organisations that is dedicated to solving water issues; from simple packaged pumping stations right through to large treatment plants.

Changing customer requirements

Government regulation and increased awareness around the issues of energy and water conservation have all played a part in changing customer requirements. The basic premise of their needs is the same today as it was 50-60 years ago but the factors driving these purchasing decisions are also now more heavily influenced by three key factors – to lower energy consumption, to reduce maintenance costs and as a result downtime, and finally solutions that offer resilience against flooding and illegal discharges. From the operations and maintenance teams, through to finance and procurement, achieving more for less has become the priority in the purchasing process.

For many however, the answer comes in the form of a packaged solution i.e. the combination of a pump, controller and a communications hub. Unfortunately when it comes to the specification of different components, it also means there are different suppliers involved; creating a further headache for those in the purchasing process.

The future

The greatest challenge and opportunity for manufacturers and the market alike is actually automation. With so much talk about this theme within the market, it can be difficult to truly understand what it means and its benefits for the water industry. Being able to see how pumps are performing from a remote location is part of this but it also has the potential for so much more.

For many years the pump has been specified and seen in isolation, however, when viewed as being part of a wider system, it has the potential to improve reliability and increase efficiencies even further. Water utilities and operations teams equally don't have too long to wait for such a solution – the future is already here thanks to Xylem's recently launched Flygt Concertor, the world's first wastewater pumping system with integrated intelligence.

The new technology is designed to automatically deliver optimal pumping performance, while at the same time significantly reducing the total cost of ownership. What is truly unique about the solution, is its integration of all components; the processor, software, electronics, sensors, power electronics, a synchronous electric motor as well as state-of-the-art pump cleaning hydraulics – all within a submersible shell.

The intelligence actually comes from two key factors; firstly, the system is designed to deliver optimal performance outputs automatically and secondly, the pump system can sense the environment in which it is working, as well as the load it is subjected to, and then adjust its behaviour to meet the end-users requirements.

It brings a whole new meaning to pumping, placing emphasis on constant power and therefore an end to overloaded pump curves and poor pump performance. Pre-engineered, with a simple set-up wizard, the system can be up and running on site within no time and customers have the ability to fine tune performance on-site or remotely.

If these developments weren't enough, a software function allows for the intermittent drawing down of liquid to pump snore before sucking out any remaining sediment. Fully automatic, it requires no manual intervention resulting in less sediment, odour and of course, cleaning.

With the addition of market leading solids handling, constant power functionality and auto reset once power and phases return to normal conditions, Concertor is a force to be reckoned with.

info.xyleminc.com/flygt-concertor-uk-english

Noise source location passes Grundfos demo challenge

Pump manufacturer sets tough challenge to decide supplier for its acoustic array

Global pump manufacturer Grundfos has enhanced its noise source identification capabilities, with a system based on a microphone array containing 108 microphones and optical camera in the middle.

Based in Denmark, Grundfos' state-of-the-art laboratory carries out sound measurements to ensure its pump units are quiet enough for domestic use and industrial demands - and to locate any potential causes of reliability issues.

To improve its ability to locate very small noise sources during product development, the company approached Brüel & Kjær for a solution. Grundfos set up a challenging test by using one of its well-functioning pumps and rigging it with two tiny, movable sound-sources. During the test, Brüel & Kjær demonstrated how its complete noise source location system could identify the sources' various frequencies and levels, producing a sound map that clearly visualized the sources, all in a short space of time.

The system will enable Grundfos to identify noise sources at a wide range of distances. At medium-distances, the array uses beamforming technology, while - to pinpoint sources close up - it uses near-field holography methods.

Many conventional arrays cannot perform accurate measurements at both near and medium distances, but the unique geometry of this array makes it highly versatile.

More information about Brüel & Kjær's noise source identification tools is available on the company's website:
http://www.bksv.com/Products/transducers/acoustic/acoustical-arrays

Exclusive for Gissing with new Börger Pumps deal

Slurry handling equipment specialist Gissing FE (Farm Equipment) have become the exclusive distributors of Börger's proven range of pumps, macerators and separators for the UK agricultural market.

The fourth generation family business, who supply super tankers, surface applicators and hose handling systems, will now develop new opportunities for Börger's products, which are particularly suited to agricultural applications.

Jason Gissing, Director at Gissing FE, commented: *"This new partnership with Börger is a very good fit. They make great products and like us, as a dedicated family business, firmly believe in top quality engineering and helping customers by delivering long lasting solutions"*.

David Brown, Managing Director of Börger UK, added: *"Gissing FE are good, trusted people to work with, whose outstanding knowledge and experience of the agricultural market gave us every reason to join forces. We look forward to seeing the benefits that can be gained by the combined efforts of two very forward-thinking, innovative companies"*.

One of the factors in Gissing FE's decision to bring Börger's equipment to the agricultural sector is the beneficial Maintenance-In-Place feature, which allows quick and easy replacement of all fluid wetted parts without the removal of pipes, drives or other components. Maintenance can be carried out with just basic tools, making a big reduction in downtime.

Gissing FE, founded in 1938 by George Edward Gissing, is now spearheaded by Mark, Jason and Wayne Gissing from the company's headquarters in North Lincolnshire.

www.boerger.com / www.gissingfe.co.uk

Neil Langdown, Group Managing Director of Hidrostal (GB) Ltd, receiving the Award on behalf of Bedford Pumps

Bedford Pumps are Pump Industry Award Winners!

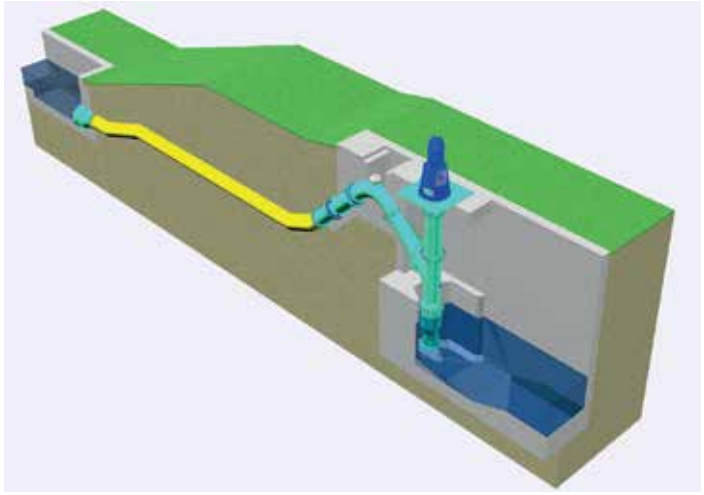
Bedford Pumps are delighted to have been crowned Winners of the prestigious **Environmental Contribution of the Year** category at the 2016 Pump Industry Awards which took place on Thursday evening, 10th March.

The accolade was presented during a glittering Awards Ceremony held at the Crowne Plaza Hotel, Heythrop Park, and hosted by BBC News Presenter, Mary Rhodes. The award was one of eight presented on the night.

Bedford Pump's received their Award for their work on a Fish Friendly pumping scheme which saved Stakeholders £3M. Bedford Pumps' Fish Friendly pumps successfully pass eels and fish in compliance with the EU Eel Regulations. For this scheme the company worked closely with Peter Brett Associates to evolve the civil engineering and pipeline design at Webb's Hole Pumping Station to carefully mitigate damage to eels and fish whilst at the same time delivering stakeholders £3M in capital savings against their national framework estimate. The station, which also includes the creation of some bird habitat, is the first of its kind to fully embrace the regulations from concept through to commissioning.

The Pump Industry Awards 2016, held in association with the BPMA, not only ensures that the companies involved receive recognition for their achievements, but with the aid of a charity raffle also manages to raise funds for charity. This year they raised an impressive £1800.00 for WaterAid.

www.bedfordpumps.co.uk / www.fishfriendlypumps.co.uk



A fully fish friendly Pumping Station design

Charity begins at the Conference Dinner

Although the Pump Centre Conference dinner is a time for Pump Centre members and their clients to network in a very social and entertaining environment, there is a serious side to the evening's proceedings. At the dinner the Pump Centre hosts a charity raffle, a different charity is selected every year, this year the chosen charity was ELHERS DANLOS SUPPORT UK. The raffle is supported by the Pump Centre and its Members who donate a great selection of prizes. To help raise awareness of the work undertaken by the charity Sarah Hamilton (Communities Manager) from Ehlers Danlos Support UK gave a short presentation before the conference dinner.

Thanks to the support of all the dinner guests the raffle, which was hosted later in the evening by master of ceremonies Jamie Sutherland, raised over £4700.00 on behalf of the charity.

For more information about Ehlers Danlos Support UK go to http://www.ehlers-danlos.org

Sarah Hamilton (Communities Manager) from Ehlers Danlos Support UK

KSB supply pumps to the Renfrew Flood Prevention Scheme on the River Clyde

KSB and Ferrier Pumps Ltd recently continued their long standing partnership working on a flood prevention scheme for Renfrewshire Council. This involved planning and collaboration on the front end design, pump testing, supply, installation and commissioning of all the pumps and ancillary equipment. The project involved KSB supplying four variable speed submersible pumps from their axial flow Amacan pump range and one variable speed sump pump of type Amarex KRT, to the North Renfrew Flood Prevention Scheme near Glasgow. KSB also supplied the 800mm diameter pump discharge canisters which are currently installed in the Storm Pumping Station situated on the south bank of the River Clyde.

The flood prevention scheme will protect more than 300 homes and businesses in North Renfrew and comprises a 3m high embankment and a new underground pumping station at the Mill Burn at Fingal Road. The embankment, which runs westward for 1km from Ferry Road, provides a barrier against direct flooding from the Clyde. The pumping station containing KSB pumps will ensure that tidal surges on the Clyde do not cause the Mill Burn to overflow and flood local properties.

The new scheme will see an end to periodic flooding which has affected many homes and businesses in the area at least once a year. The combination of tidal surges and overflow from the burn has created flooding problems in the north end of Renfrew since the area was reclaimed from the river 300 years ago.

The pumping station provides a capacity of 5.5m³/s to provide standard protection against tidal flooding from the River Clyde and fluvial flooding from Mill Burn. The pumping station's maximum flow rate has been specified to cover a 1 in 200 year flood event. KSB Amacan pumps were chosen for this station as their characteristics ideally suit the transfer of very high flows of water at low heads. KSB's technically advanced pumping equipment is well-suited for flood control and the Amacan pumps ensure flood-prone areas are reliably drained.

KSB Amacan submersible pumps are typically used in land drainage applications and have a compact and slim design, but are extremely powerful. The Amacan's slim design makes the submersible pump ideal for installation into narrow discharge canisters. Ferrier Pumps Ltd carried out the mechanical installation at the Renfrew project site and found the pumps were easy to install as the Amacan pump's own weight ensures self-centering seating of the O-ring seals in the discharge canisters, a simple but effective design feature. The Amacan pumps come with bearing temperature monitoring, thermal motor protection and leakage sensor in the motor. They also have a low-vibration hydraulic system and a bellmouth optimised for vortex-free inflow making them an excellent choice for the Renfrew project.

Pump discharge rates have been defined as 1253l/s (at 7.8m pumping head), 1560l/s (at 3.3m pumping head) and 1375 l/s (at 6.1m pumping head) under normal conditions. The maximum design flow for the station has been defined as 5500l/s, which is based on four pumps working simultaneously and delivering 1375l/s each. The pumps selected offer the best efficiency over the required operating points. The number and speed of operational pumps is controlled by PLC system, based on the water level in the pump well. Well level is continuously monitored by an ultrasonic sensor and pump operation is determined by optimisation of efficiency. When the River Clyde levels begins to rise and the water level reaches the lower limit of the modulating band the first KSB Amacan pump will be initiated at minimum speed. If the inflow is less than the pumped outflow at minimum speed, the level in the pumping station will fall and the pump will be stopped at the defined ***"cut out"*** level.

If the inflow is greater than the minimum pump discharge rate, the level in the wet well will continue to rise after the Amacan pump starts. The sump water level will now be within the modulating band and the pump controller will modulate the speed of the pump in proportion to the level until the pump can stabilise the level at, or around the set-point level. If the duty Amacan pump operates at full speed and the level continues to rise, a second Amacan pump will be initiated ramping up from base speed until the inflow can be matched with a level within the modulating band. When there is a heavy rainfall, all four Amacan pumps can be called to run depending on the water levels in the main sump tank.

Ferrier Pumps also installed in the main sump chamber a KSB Amarex KRT submersible solids-handling centrifugal

pump, specifically manufactured in abrasion resistant materials to remove storm water as well as handling a relatively high concentration of solids in the pump station. This variable speed pump is used for sump drain down following cessation of a storm event.

KSB have also supplied the pump discharge canisters, which were designed by KSB at their UK Head Office in Leicestershire, and were digitally prototyped and tested using the latest 3D design software. The canisters were manufactured by Powerrun Project Management Ltd of Keighley and each 800mm diameter canister was supplied to site in 3 off individual double flanged sections with a combined weight in excess of 3000 Kgs and an overall assembled length of nearly 10 metres. The top section of each canister incorporates a DN800mm x 180-degree open ended discharge that feeds into the discharge chamber of the pump station from where the flow gravitates away from the Clyde. After fabrication the canisters were coated with a fusion bonded epoxy coating.

Before any manufacturing of products or site work began, a report covering the testing and development work was undertaken on a physical hydraulic model of the proposed North Renfrew Pumping Station and associated discharge chamber arrangement. The model was constructed to a scale of 1/7th full size and the purpose of the pumping station model study was to investigate and confirm the pumping station hydraulics, the proposed operating philosophy and the self-cleansing characteristics of the initially proposed design. The purpose of the discharge chamber was to confirm the discharge bend geometry, optimise energy dissipation and deaeration and to assess and improve outlet losses. Where required, suitable modifications were developed in each case to optimise each component of the overall arrangement to ensure acceptable operation could be maintained across the required flow and level range and with varying combinations and number of operative KSB pumps. This report proved invaluable in preventing expensive problems, at a later date, further into the project.

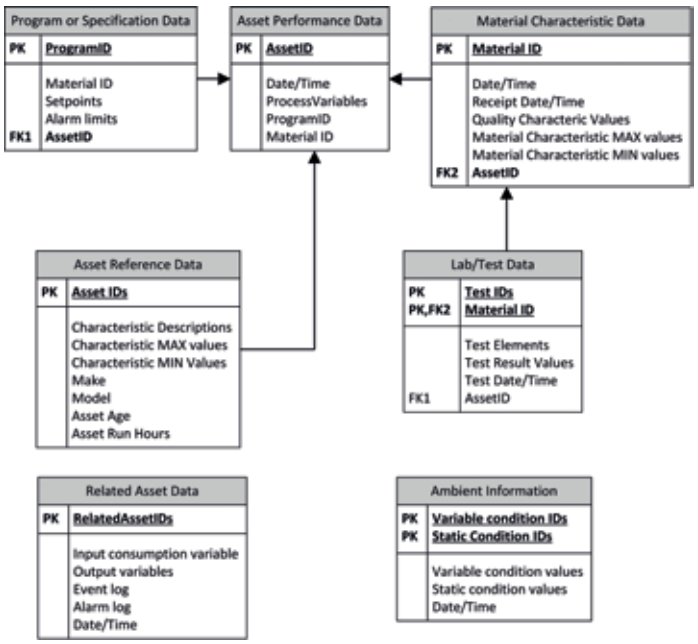
Ferrier Pumps Ltd, a KSB distributor in Scotland, carried out the mechanical and electrical installation for George Leslie Ltd who was the main contractor for the £3.6m project. The work was commissioned by Renfrewshire Council as part of the overall £10m flood prevention scheme for the town.

www.ksb.com

Applying Analytics Requires Outside-the-Asset Thinking

Improvements in communications technology, coupled with the shrinking cost and footprint of processing power are changing the rules around what's possible with remote monitoring and diagnostics tools (RM&D). But though the technical capabilities are evolving rapidly, the philosophies around effective RM&D practices are still somewhat rooted in the approaches of the past – ironically, the deployments are often too asset-centric! To really unlock value from RM&D tools, and particularly from the analytics that promise faster interpretation of fleet data, firms need to look outside the core asset themselves.

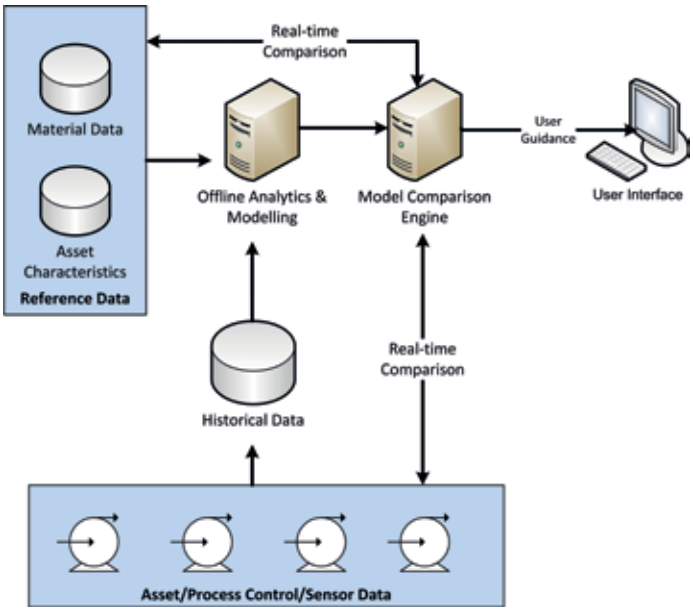
Whether searching for improved energy efficiency, higher reliability, or even a better understanding of how to apply design-for-application principles, the mix of data needed for deeper analysis will definitely include asset and process data, but will generally also require reference data, ambient condition data and even what might be called *"material"* data – information about the characteristics of what's moving through the system.



A simplified map of data elements that could be included in an analytics project related to pump efficiency or reliability

From the mix of data sources, it's clear that each of the improvement opportunities noted above not only requires adding non-asset data to the mix, but the number of variables that might be included in an analysis project is high enough to demand some level of analytics tool support (most of us aren't good at maths once past 2 or 3 dimensions). Analytics allow an engineer to rapidly develop models based on past behaviours and event patterns, and then test such models for their future predictive value against a category or type of asset – not just an individual machine. The key results analytics should deliver are:

- A correlation of all the inputs that seem to impact the factor for which you're solving (reliability, energy efficiency, etc)
- A characterisation of the strength and sensitivity of those correlations
- An ability to model different what-if scenarios by pegging the values of certain controllable factors and re-running the models



With a trusted model able to deliver predictive insights, RM&D centres can incorporate real-time comparisons to models in their toolkit

Armed with these insights, a firm can then re-define control strategies and maintenance plans (and related staffing and MRO materials needs), or even re-assess design principles for pump systems in more complex applications, where previously hidden interactions between assets and materials had introduced problems or inefficiencies. With some fleet owners seeing improved efficiency rates, alongside failure rates that have halved or better, the value of *"thinking outside the asset"* is clear!

www.kerrcoautomation.co.uk

Reliable Blowers for Air Injection into Aeration Tanks

The Schlammersdorf-Vorbach sewage treatment plant processes household waste water for 2,900 residents of the communities Schlammersdorf and Vorbach in the Upper Palatinate region of southern Germany. Air injection into the aeration tanks is carried out by Busch Tyr blowers. Oxygen in this air is required to break down carbon and nitrogen compounds in the waste water during the aerating stages of the process. In the non-aerating stages, air impulse injection is used to mix the tank contents to a homogeneous consistency.

Sewage treatment plant operated by the Schlammersdorf-Vorbach waste water treatment authority

The sewage treatment plant is owned by the waste water treatment authority in Schlammersdorf-Vorbach, and was commissioned in 1996. The receiving water is the Creussen, a minor river that flows beside the plant. The plant uses the activated sludge process with simultaneous sludge stabilization. This purification process was chosen due to the relatively large fluctuations in demand generated by the nearly 3,000 local residents served by the plant. The entire system was installed by D.W.I. Service Sued, which also provides technical support. One of the areas in which D.W.I. specializes is the provision of technical services for waste water treatment plant, and the company works closely in this sector with the vacuum and overpressure specialists Busch.

After passing through the raking and sand trap systems, the waste water flows through a siphon into an aeration tank with a depth of about four meters and a capacity of 1,100 m^3.

The simultaneous sludge stabilization achieved by extending the aeration time oxidizes or mineralizes the organic impurities. The excess sludge extracted is more or less stabilized and almost odourless.

The air injection into the aeration tank has been carried out since July 2015 by two Tyr blowers supplied by Busch Vacuum Pumps and Systems. These modern blowers were installed after the previous two blowers supplied by a different manufacturer failed completely within a short period. As the sewage treatment plant was unable to operate without these blowers, a solution had to be found rapidly. Busch was able to supply a replacement blower immediately, it was installed by D.W.I. Service Sued and the plant resumed operation within 48 hours. This temporary blower was later replaced by two Busch Tyr blowers installed in the production building. The Tyr blowers deliver intermittent overpressure at 0.5 bar with constant volume flow. As the maximum pumping speed is required only in cases of extreme contaminant load, the control system is programmed to operate both Tyr blowers at two different speeds without the use of frequency converters. This means the total pumping speed may be set to four levels, allowing enormous energy savings to be achieved. With this arrangement the control system runs the blowers for a maximum of 12 hours a day. The oxygen content in the aeration tank is monitored continuously by the control system: if it falls below a minimum value, the blowers are started automatically. The control system can determine from the oxygen content whether one or two blowers are required, and at what speed they should run. An adequate supply of oxygen is essential to metabolize carbon compounds and to oxidize ammonium nitrogen during the nitrification stage. In the subsequent denitrification stage, the nitrogen decomposition by-products are converted to nitrogen gas by microbial action. This gas is released to the atmosphere, which itself consists primarily of nitrogen.

The operating costs of a sewage treatment plant can represent a large proportion of annual expenditure for small towns and communities. The community authorities operating these systems and technical management both agree that sewage treatment must be carried out with the maximum possible economy and energy efficiency. Personnel costs at the Schlammersdorf plant have been reduced by a high degree of automation and the participation of the Grafenwoehr utility company, which receives plant alarm messages automatically. In practice the plant is inspected every working day, and all parameters relevant to its operation are examined. Technical equipment for the continuous process has been chosen for maximum energy efficiency. For example, the agitators originally used to mix the contents of the aeration tank were removed and replaced by impulse air injection. The two Tyr blowers now perform this function by introducing air through non-clogging membrane inlets at the bottom of the tank. Electrically driven agitators are no longer required.

After a year of operation (July 2016), Gerhard Maier and Johannes Zinnbauer of the Grafenwoehr utility company expressed their complete satisfaction with the two Busch Tyr blowers, which have made an energy efficient and reliable contribution to the purification of waste water in the aeration tanks.

www.busch.co.uk

Photo credits: Uli Merkle, Busch Dienste GmbH

One of the two Busch Tyr blowers used for air injection into the aeration tanks

Atlas Copco puts the air into aircraft maintenance at Monarch's flagship facility

A compressed air system from Atlas Copco is playing an integral role in supporting maintenance procedures carried out by Monarch Aircraft Engineering Limited (MAEL) within its multi-million pound, giant hangar facility at Birmingham International Airport.

MAEL is the engineering division of The Monarch Group. Its 110,000 sq ft state-of-the-art facility in Birmingham complements the company's existing engineering operations at London Gatwick, London Luton and Manchester airports, and supports MAEL's ability to provide both existing and new customers with first class maintenance, repair and overhaul services.

Compressed air plays an essential role in aircraft maintenance procedures so special consideration of the air supply access locations, such as positioning flexible hose reels and siting floor channels to limit clutter and allow proximity to the point of use, was all part of the original system design and procurement process. This approach has enabled optimum utilisation of floor space to accommodate simultaneous maintenance operations on a mix of wide-bodied and narrow-bodied aircraft to be carried out at any time.

The Atlas Copco compressor system, supplied and installed by the company's premier distributor, Air Kraft Ltd, based in Coventry, comprises two GA30 VSD FF full-feature, rotary screw compressors and ancillaries. These compressors, each with an integrated refrigerant dryer, supply 7bar quality air for specific applications ranging from combination with air movers for the ventilation and emptying of aircraft fuel tanks, to the operation of air tools for structural fastening and assembly tasks and the blind riveting of fuselage panels.

A particular feature of the system is the 300 metre, multi-drop air ring main, constructed from Atlas Copco's AIRnet modular piping system. The pipework is made from robust, lightweight, powder-coated aluminium tube and designed for easy, low-cost installation with a large selection of engineered polymer fittings. Readily adaptable, AIRnet low-friction, seamless pipework is corrosion free so it minimises pressure drop in the system and effectively contributes to energy efficiency.

Commenting on the MAEL's purchase decision, John Swords, the company's Team Leader of Maintenance, Planning and Control said: *"We were sufficiently impressed with the performance of the Atlas Copco compressed air solutions already installed at our Luton maintenance operation that there was no hesitation in specifying the system for this milestone development with complete confidence."*

The MAEL facility in Birmingham can accommodate almost every aircraft type in its two bays. It incorporates industry-leading design and build standards and is one of the first to have the capacity for Boeing 787 Dreamliner maintenance, with sufficient capacity for other wide body aircraft, such as the Boeing 777, 747 and Airbus A350. The hangar is large enough to accommodate two Boeing 777-300ER aircraft or 10 narrow-body aircraft and contains a number of component-repair and back shops. The dimensions are impressive; the vast building, covering around 2.5 acres is big enough to house four full-size football pitches, 2,400 Minis or 450 double decker buses.

www.atlascopco.co.uk

Pump Centre Conference &

The Pump Centre conference and exhibition took place at the Telford International Centre on Thursday 12th May. The event was attended by over 1100 visitors predominantly from the water industry supply chain. Visitors had free access to all areas, including:

- The main technical conference based on the subject of *"Innovative Pumping – Challenging the norm"*.
- 16 breakout sessions on a wide range of interesting engineering and water industry topics.
- An exhibition of approximately 100 of the water industry's leading manufacturers and suppliers – covering a floor area of 5000sqm.
- Other attractions such as – the New Product and Information Zone, and pump demonstration area.

Whats our visitors say:

"We get to see the right people – the people who make the decisions within the water authorities .... It is a must! The event has grown over the years".
David Brown (Börger)

"The networking is fantastic – it's the number one event in the industry to come to".
Alistair MacKinnon (Pulsar Process Measurement)

"This is generally the only exhibition we tend to attend .... Because we understand everything is here, this is our primary event of the year".
Keith Solts (Environment Agency)

"We can get to talk to the users and learn from them, in one place".
Nick Battersby (REID Lifting)

"The benefits are that we can promote ourselves to high quality people".
Alex Lloyd (Jacopa)

"We will definitely be here next year – hopefully contributing to the conference package, seminars".
Andrew Barry (Xylem Water Solutions)

"The workshops and the training workshops echo what the Pump Centre is all about, which is about educating people about this particular field [pumps & pumping]".
Jonathan Choksey (Mott MacDonald)

"When you look at the audience that the exhibitors get, it is a very targeted audience – these are the people that are interested in buying your products and services".
Bob Went (Pump Centre Chairman)

Exhibition Review 2016

The Derek Jackson Award

This new award is in recognition of Derek Jackson, the former MD of Hidrostal UK Ltd, who sadly passed away earlier this year. Derek had been an active supporter of the Pump Centre and in recognition of his achievements in the pump industry and for his support to the development of Young Engineers, and with the agreement of Derek's family, the Pump Centre were honoured to announce the award in his memory at the Pump Centre Conference dinner on 11th May.

The Derek Jackson award will be given each year to one candidate in the Pump Centre Young Engineer Awards competition who, in the opinion of the judges, has been outstanding and warrants recognition. This may or may not be an award winner. The Award will recognize achievement and hopefully encourage others to develop their careers working with pumping systems or in the pump industry.

At the conference dinner Bob Went, the Pump Centre Chairman, announced that the first winner of the Derek Jackson Award was Charlie Lake, an EM & I apprentice with Wessex Water - who particularly impressed the judges with his experience, application & presentation.

Unfortunately, Charlie was unable to attend the award ceremony, but he had a good excuse because it clashed with a meeting with Prince Charles. In his absence the award was accepted by Charles Fairclough of Wessex Water and a note from Charlie was read out to the audience.

Ladies and Gents.

Firstly I am very sorry I could not make tonight to collect this award, I have been requested by Royal appointment to meet Prince Charles at my new house on Duchy Lane to discuss the benefits and opportunity of owning a house on the estate.

I know this may seem a poor excuse for not being here but given he might be the next King of England; I didn't want to be the first beheading of this reign.

Thank you to the Pump Centre for organising the awards and apprentice challenge, which I tried my best to win, hoping to go one better next year.

Thank you to all the companies that are involved to make these awards possible.

It is a great honour to be the first to receive this award; I am very pleased to have been selected given my competition.

Wessex Water take great pride in their apprentice program and this award shows the quality of the apprentices in the program, we won a couple of years ago and are keen to win it again.

Charlie Lake of Wessex Water – Winner of the Derek Jackson Award

We will be back next year.

Thank you to Charles for collecting the award on my behalf, have a great night.

Charlie.

Snap shots from the Pump Centre Conference dinner

Not only the splendid company but the superb menu, prizes and entertainment made sure everyone was kept entertained at this year's pre Conference Dinner. Thanks to everyone's generosity, the evening raised more than £4700 for good causes – another record that we will do our best to beat again next year.

The future of engineering

The future of engineering in the UK was looking very bright at the Pump Centre's Young Engineer of the Year awards. The award ceremony was part of the Pump Centre's annual conference dinner held in the Ironbridge Suite of the International Centre, Telford.

The awards were hosted by Bob Went, Chairman of the Pump Centre and attended by over 500 hundred professionals from the water and pump industry. For many years the Pump Centre has encouraged and supported the development of Young Engineers in the UK.

On the night, awards were presented in two main categories:

- Apprentice / Technician Engineer
- Professional Engineer

There was also a special judge's commendation, the Derek Jackson Award, presented to one of the short-listed Young Engineers, who in the judge's opinion, has already shown an outstanding contribution to engineering (for more details see page 15).

If you know of a Young Engineer within your business or supply chain that you feel deserves recognition for their work and achievements please consider nominating them for the Pump Centre Young Engineer Awards 2017.

For more information and to request a nomination form, email info@pumpcentre.com

Young Engineer of the Year – Professional Category

Winner: James Ballard (Severn Trent Water)

A photo of James Ballard accepting his award from Bob Went (Pump Centre Chairman). James and his colleagues from Costain presented a technical paper at the Pump Centre Conference, on the day after the award ceremony, entitled "Intelligent Sewage Pumping Station MCC"

Young Engineer of the Year – Apprentice / Technician Category

Joint Winners: Tim Battersby (Reid Lifting) & Scott Proverbs (WES Ltd)

Left photograph Tim Battersby (Reid Lifting) and right photograph Scott Proverbs (WES Ltd) accepting their Young Engineer of the Year commemorative certificates from Bob Went, Pump Centre Chairman. This was the first time since the awards were launched, almost 10 years ago, that the award had to be given to two candidates because the decision was too close to call.

Pump Centre Pump Project of the Year 2016

The Pump Centre *"Pump Project of the Year"* concept was launched in 2015. The aim is to promote one pump related project every year and highlight the excellent work carried by the project team.

This year a project entitled *"Severn Trent Water Melbourne real time pump and turbine network optimisation"* submitted by a collaborative team from Riventa Ltd & Deritend Ltd, working on behalf of their client, Severn Trent Water was selected by an independent panel of judges. The article below is a summary of the project and the work they undertook.

The Pump Project of the Year team with the Pump Centre Chairman: Left to right, Paul Rothera (STW Melbourne manager), Tom Clifford (Riventa Ltd), Bob Went (Pump Centre Chairman), Ian Patterson (STW Energy Manager) and Bill Edwards (STW Energy Manager)

Severn Trent Water Melbourne real time pump and turbine network optimisation

Tom Clifford B.Eng, ACSM, C.Eng, MIMMM. Consultancy Director, Riventa Ltd

1 Synopsis

The Melbourne Area Network has always suffered from large variations in energy use and numerous historic investigations had not uncovered the reasons or best operating policies. The complex algorithms developed as part of the work enable Severn Trent Water (STW) to accurately schedule operation over a set horizon, meeting the demand with very appreciable energy cost reductions - a process simply too difficult for operational staff to do by experience alone. The structured and unbiased methodology means that the annual cost of energy has reduced from £4.5M by 9%. The wealth of data has also identified a further £200,000 of savings available through targeted investment.

2 Introduction

The UK Water Industry is coming under increasing pressure to improve the efficiency of its operations.

The start of the sixth Asset Management Period (AMP6) in 2015 has lead to a longer term view on how costs should be saved. Whereas previous savings have been targeted through short term capital expenditure, AMP6 has concentrated on the minimisation of total expenditure, reflecting the need for capital investment to reduce overall operating costs in the long run.

Severn Trent Water has embarked on a significant programme of operational efficiency savings and capital expenditure efficiency savings through targeted investment.

A key part of Severn Trent Waters infrastructure is the Melbourne Area network near Derby. This system supplies the Smisby, Ragdale and Hallgate service reservoirs and consists of the following elements:

- 1 water treatment works;
- 7 pumping systems;
- 2 reservoirs;
- 1 turbine and break tank;
- Abstraction from a river.

The Melbourne network is subject to 6 different electricity tariffs per day and

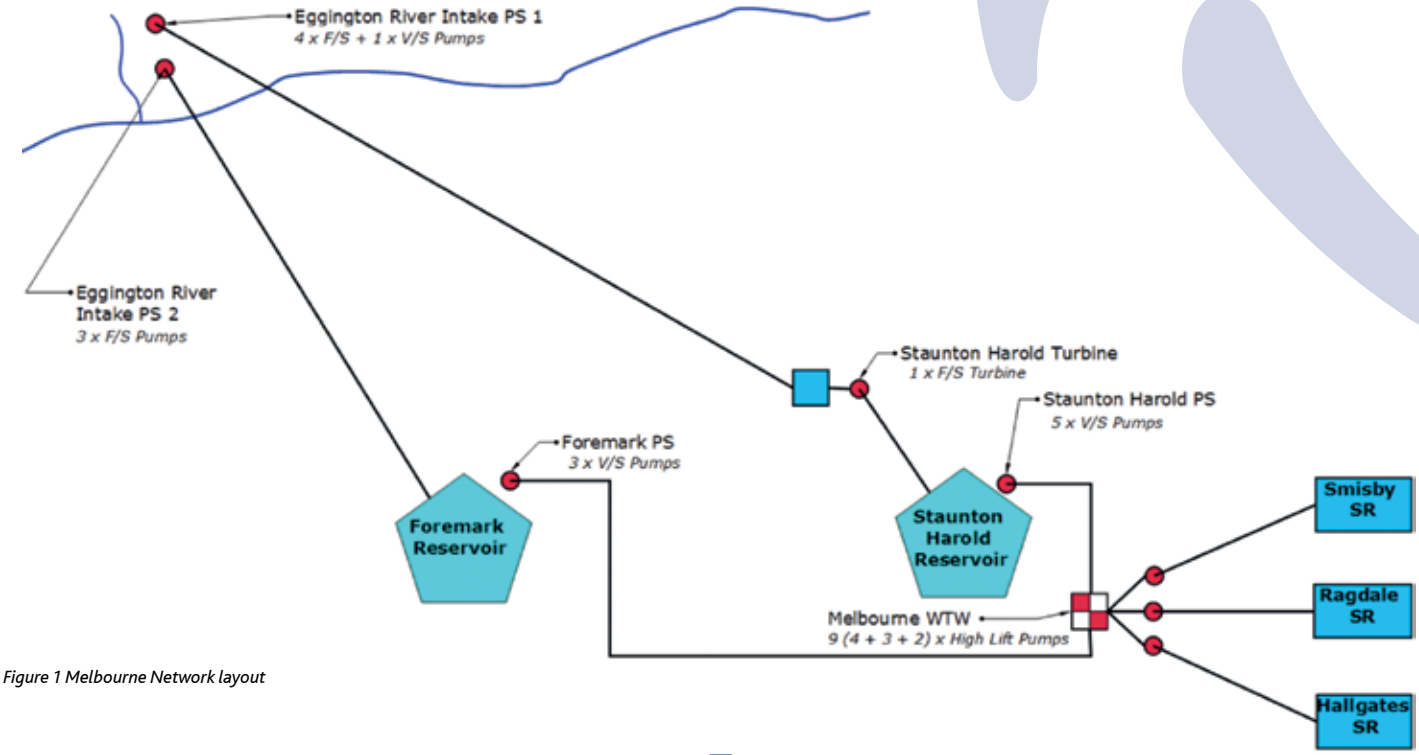


Figure 1 Melbourne Network layout

periodic Triad events resulting in an energy cost of operating the network in the order of £4,500,000.

Forming a significant part of its operations, Severn Trent Water has sought to minimise this cost through efficient use of its existing assets and capital investment for longer term reductions.

As shown in Figure 1, the Melbourne network draws from the River Dove using two pumping stations which deliver water to Melbourne Water Treatment Works through two routes via the Foremark and Staunton Harold reservoirs. This network distribution provides a multitude of pumping combinations that can be used to meet a required demand.

Riventa and Deritend, working in partnership with Severn Trent Water, have applied their patented pump performance monitoring systems across the Melbourne network pumping stations to assess individual pump and station efficiencies and derive live network models. Utilising this data, it has been possible to implement an automated Decision Support System (DSS) to provide recommendations as to which pumps to operate, what speeds, and when, to achieve the lowest overall operating cost whilst taking account of variable tariffs, storage, demand and asset performance.

The specific goals of the project were:

- Provision of a systematic method of identifying the lowest cost operation;
- Communication of real-time operational recommendations through a Decision Support System (DSS) to operational staff.

3 Technology overview

Two key technologies were amalgamated to provide a network optimisation methodology that was integrated into a unified DSS. These consisted of thermodynamic pump performance measurement for individual pump and station efficiency analysis, and live hydraulic modelling to assess network routes and their hydraulic profiles.

3.1 Thermodynamic pump performance measurement

Pump station optimisation can be achieved through informed scheduling and speed selection of pumps to achieve a required demand at the highest possible efficiency. In order to achieve this, it is critical to establish both individual pump and system curves which require measurement of head, power, efficiency and flow rate.

The conventional method for performance measurement computes the output power of the pump through measurements of differential pressure across, and volumetric flow rate through, the pump. The input power to the pump is usually obtained by measurement of gross electrical power and an assumption of motor efficiency. This method is often costly to implement on site due to the requirement for a flow meter to be installed on each pump which is not always possible due to physical space constraints which also limit the accuracy of application.

As introduced in our 2014 Pump Centre paper, the thermodynamic technique for pump performance measurement utilities an enthalpy – entropy mapping method to determine pump efficiency without the need for direct measurement of flow rate.

The premise is rooted in fundamental thermodynamics in that if you measure any two thermodynamic state variable's (TSV) (which include temperature and pressure) then you can calculate any other TSV (which include enthalpy and entropy).

The conventional definition of hydraulic efficiency is shown in Equation 1.

$$\eta_H = \frac{OUT}{IN} = \frac{Water\ Power}{Shaft\ Power} = \frac{\rho\ g\ H\ Q}{P_e\ \eta_m}$$

Equation 1

Where η_H = Hydraulic efficiency, ρ = Density of fluid (kg m^{-3}), g = gravity (ms^{-2}), H = Differential Head (m), Q = Flow rate (l/s), P_e = Electrical Power Input (kW), η_m = Efficiency of motor.

Considering this in terms of a systems losses leads to Equation 2.

$$\eta_H = \frac{OUT}{IN} = \frac{OUT}{OUT + LOSSES} = \frac{1}{1 + \frac{LOSSES}{OUT}}$$

Equation 2

Substituting the definition of thermodynamic losses (Equation 3) and definition of output power to the fluid (Equation 4) into Equation 2 leads to the definition of hydraulic efficiency shown in Equation 5.

$$LOSSES = \rho\ C_p\ \Delta T\ Q$$

Equation 3

Where Cp = Specific Heat Capacity of the fluid (kJ/kg°K), T = Temperature differential across the pump (°K)

$$OUT = \rho\ g\ H\ Q$$

Equation 4

$$\eta_H = \frac{1}{1 + \frac{\rho\ C_p\ \Delta T\ Q}{\rho\ g\ H\ Q}} = \frac{1}{1 + \frac{C_p\ \Delta T}{g\ H}}$$

Equation 5

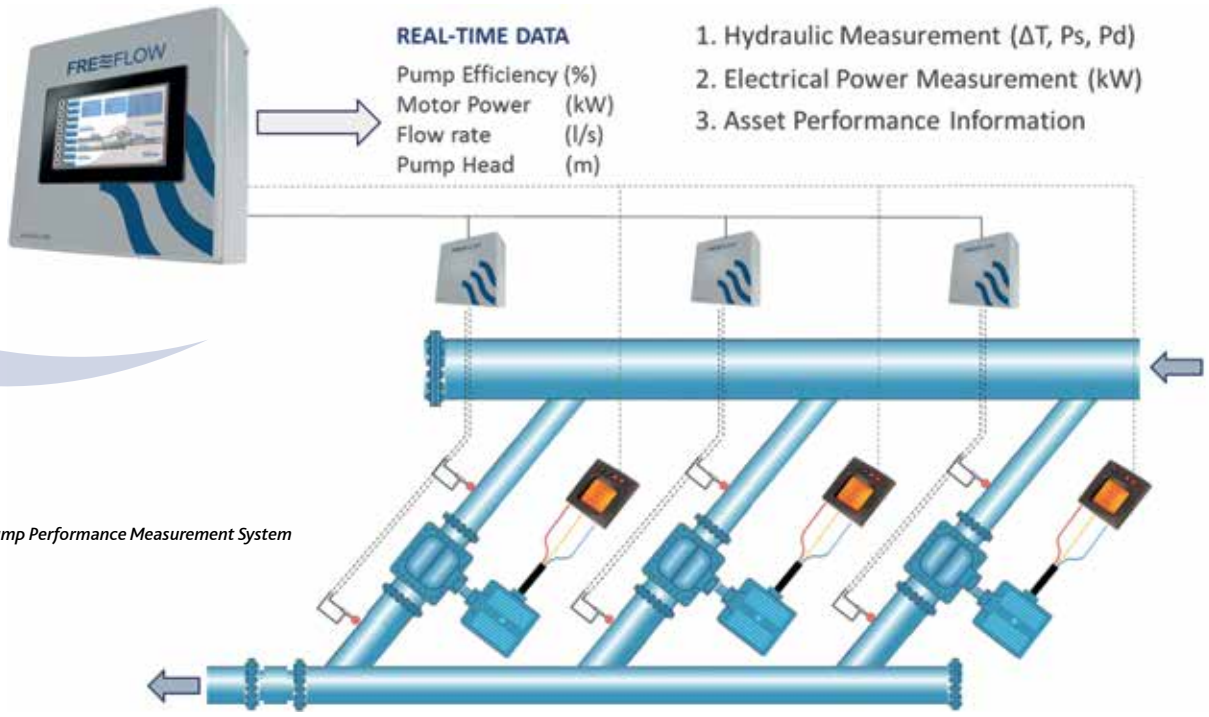


Figure 2 Pump Performance Measurement System

Equation 5 demonstrates that the efficiency of a pump can be calculated by measurements of pressure and temperature only without the need for flow rate measurement.

Using this definition, the flow rate can now be calculated through rearrangement of Equation 1 as shown in Equation 6.

$$Q = \frac{P_e \times \eta_m \times \eta_H}{\rho \times g \times H}$$

Equation 6

The key benefits of using this method of pump performance measurement are:

- Comparatively low cost for site use purchase;
- Simple installation requirements and as such is low cost to install;
- Not dependent on straight lengths of pipe to effect an accurate measurement;
- Well suited to on site application, generally for heads >15m;
- Has head limitations to obtain the best accuracy.

A typical installation schematic of a thermodynamic system is shown in Figure 2.

3.2 Station level optimisation

Using the thermodynamic pump performance measurements, through a combination of real-time analysis, and review of logged data, the following information can be quantified at station level:

- Individual pump curves;
- System curve(s);
- Demand profile (load characteristics).

With this data an automated decision support system (DSS) can been created to compute the most efficient combination of pumps and pump speeds, in real-time, to meet the current operation duty – or any other specified duty, something that is hard to achieve manually due to the sheer number of combinations available.

A station with 10 fixed speed pumps will have 1023 possible combinations to choose from and if they are variable speed pumps the combinations are infinite.

As with dynamic systems like distribution zones or tank level changes, where the system curve is not constant, the head and consequently pump efficiency will constantly change. Use of real-time data allows the DSS to adapt to these changes and compute the efficiency (or specific power) of all possible combinations under all possible circumstances and recommend the combination that provides the lowest possible operating cost for the available plant.

Use of the DSS on previous projects in both European and Asian water industries has shown significant benefits in minimising operating costs at a station level with savings of up to 14% on annual power bills with payback periods as low as 2 months.

Though the use of a DSS in combination with thermodynamic measurement techniques allows for minimisation of station operating costs, when considered as part of a network of other pumping stations and storage, additional factors can influence the overall network operating costs meaning each part cannot be considered in isolation.

3.3 Network modelling

Traditional approaches to network optimisation involve the development of static hydraulic models and optimisation algorithms.

Water distribution systems have a high degree of dynamic parameters which have the tendency to cause inaccuracy in the model simulation result. To overcome this the real time hydraulic models are generated based upon the latest pump, system and demand data acquired from the distributed FREEFLOW systems.

3.4 Combined network optimisation

Combining station level measurement and traditional network modelling techniques, it is possible to generate hydraulic models in real-time to overcome problems of the current state of the art.

Though an optimised station helps to minimise pumping costs, certain stations may be more efficient than others for certain combinations of demand and time. Additionally, dynamic system curves, due to demand variations and network configurations changes add further complexities.

By combining the two techniques, it is possible to create an advanced automated DSS which utilises the real-time pump efficiency data from station level thermodynamic pump performance measurement and combines it with the network hydraulic data to provide a constantly updated hydraulic model, removing some of the traditional assumptions required in network optimisation. This hydraulic model can then in turn be used to schedule pump operation and speeds, simulate / predicting reservoir and service tank levels and optimising time operation relative to electrical tariffs.

4 Project approach

The creation of a network optimisation system required two distinct pieces of work:

- Provision of real time measurements of pump, station and network performance in terms of efficiency and specific cost;
- Design of a custom Decision Support System (DSS) to enable operators to have real time visualisation of pump efficiency and provide instructions on how to operate the network, meeting demand, at the lowest cost.

4.1 Equipment installation

The first step was to install real time pump and turbine efficiency monitoring equipment on all machines at these stations, a total of 26 pumps.

Each station installation consisted of a Human Machine Interface (HMI) as shown in Figure 3, connected to a series of FREEFLOW Data Acquisition Units (DAU) mounted adjacent to each pump as shown in Figure 4. On each pump, a temperature and pressure transducer were installed in tappings on the suction and discharge position side of each pump as shown in Figure 5 which were connected to the respective DAU. Power meters were also installed on each pumps operating panel as shown in Figure 6 and connected back to the HMI.

The HMI collates the data from the individual pump DAU's at a station level and provides the following information in real-time:

- Pump Efficiency (%);
- Motor Power (kW);
- Flow Rate (L/S);
- Pump Head (m).

The pumping stations were located within an approximate 10 mile radius of the main Melbourne Water Treatment Works which serves as the hub of operations. Due to the distributed locations of the pumping stations, a satellite broadband system was installed at each location to send data back to the control centre for

Figure 3 Human Machine Interface (HMI) (5 installed)

Figure 4 FREEFLOW Data Acquisition Unit (26 installed)

Figure 5 Hydraulic efficiency pressure and temperature transducers (104 installed)

Figure 6 Electrical power metering (26 installed)

processing by a custom DSS.

The installation of the pump performance measurement equipment allowed for the determination of individual pump head and efficiency curves and station level system curves to inform the hydraulic model.

4.2 DSS development

Utilising the data flowing back from the network stations, a bespoke DSS was created to assess and provide recommendations on pump scheduling and reservoir valve scheduling (to utilise storage potential) to achieve the lowest network operating cost.

The system works by assessing multiple combinations / scenarios to achieve a given demand.

The Melbourne network elements combine to provide the following combinations:

7 F/S and 19 V/S Pumps

(+ 6 tariffs, 3 storage, Turbine, Variable Demand)

= 1x10114 Combinations

Due to the sheer number of combinations available, a simple statistical approach would not be practical, as such, a Multi-Objective Genetic Algorithm with Artificial Neural Network and Caching technique was utilised to simulate 24 hour operation of the network, scheduling pump operation and speeds, simulating / predicting reservoir and service tank levels and optimising time operation relative to electrical tariffs.

The genetic algorithm uses the following approach to select the optimum combination and as shown in Figure 7:

1. Randomly select pump combinations;
2. Run hydraulic model, calculate cost and rank solutions;

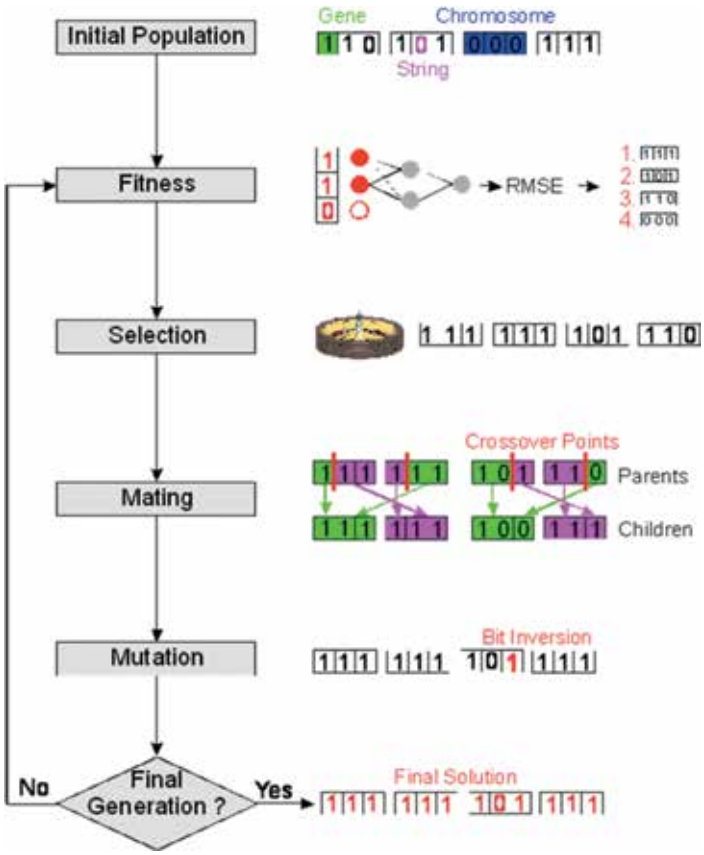


Figure 7 Genetic algorithm mechanism

3. Pick a selection of the best pump combinations;
4. Combine or 'mate' the best pump combinations;
5. Randomly change some attributes;
6. Loop the outcomes back to step 2 until answer converges.

The use of the algorithm enables the system to monitor a total of 493 parameters in real time at 5 second intervals with automated file management, analysis and reporting.

5 Project results

The use of distributed pump performance measurement and network optimisation has enabled Severn Trent Water to identify interactions within their network, enabling them to accurately schedule operations to meet the demand with significant energy cost reductions - a process simply too complex for operational staff to do by experience alone.

Savings attributable to the installation of the network optimisation system were categorised on 3 levels:

- Station Level – Those achieved through optimisation of individual stations in isolation through pump scheduling and speed selection.
- Network Level – Those achieved through optimisation of water routing and storage.
- Capital Savings – Savings potential identified through additional capital expenditure to reduce operating costs in the longer term.

From a benchmark demand of £4.5M / annum, an overall saving of 9% (£405,000) was realised through operational changes only with no additional CAPEX beyond this project resulting in a <1 year payback on the project.

In addition, a further 4.5% (£203,000) of annual savings were identified through targeted CAPEX of £300,000.

If additional capital expenditure was made and all possible sources of saving were obtained by upgrading the system to 'best practice', a saving of 19% could be achieved, equivalent to £855,000 / year.

Taking the problem at its most basic level, the network pumps water from its source to the water treatment works which is it a higher elevation. Conducting a simple hydraulic calculation to calculate the power required to raise water by this height reveals a minimum theoretical energy cost of £1.45M; the current cost is some three times greater highlighting the degree of losses (and so potential) in water distribution systems.

The impressive results have changed the way the network operates and it is intended to role the system out to other networks across the AMP6 period to utilise this new information driven approach as a key feature in targeting resources for OPEX reduction and CAPEX allocation - fulfilling the TOTEX mandate.

6 Technology potential

With AMP6 in full swing it is an imperative of UK water companies to invest with due consideration of capital and operational costs.

This project demonstrates how accurate performance measurement and an information driven approach can be used to minimise operational energy cost and target investment for maximum long term savings - all with a tangible and transparent decision making process - fulfilling OFWAT's TOTEX mandate.

7 About the author

Director of Consultancy at Riventa Ltd leading technical staff across three service centres in America, Asia, with headquarters in the UK.

Water and waste water pump energy specialists, Riventa, is a world leading organisation manufacturing instrumentation and software with the main pursuit of reducing the cost of energy within the water industry

Tom is responsible for on-site pump efficiency testing, hydraulic engineering consultancy and network modelling. Using a global network of partners, like Deritend, enables delivery of turnkey solutions with proven results for the water industry.

www.riventa.com

A history of innovation at Cragside continues with hydro-electric power from WEG

Image courtesy of The National Trust

Built in the 1800s by Victorian Engineer and Inventor William Armstrong, Cragside is credited as being the first house to be lit with hydro-electricity - and over 100 years later it is generating green electricity again from water power thanks to a WEG W22 high efficiency electric AC motor / generator.

William Armstrong was one the most prominent industrialists of his age, pioneering the use of pressurised water to power hydraulic equipment such as dockside cranes; after which he went on to introduce breach loading field artillery guns and many other engineering marvels. Towards the latter part of his career he showed a visionary attitude towards reducing dependency on fossil fuels and the need for developing renewable power sources.

Putting his money where his mouth was, he and his wife Margaret created the Cragside estate, north of Newcastle in Northumberland, there they famously planted seven million trees over an area of over 1,700 acres, together with five artificial lakes that were used to generate hydro-electricity. This innovation made Cragside the first documented house in the world to have been lit by hydro-electricity, using incandescent lamps provided by fellow inventor Joseph Swan.

As the first engineer and scientist to join the House of Lords, William Armstrong left a career legacy as well as his spectacular house, now run by the National Trust. The house contains many gadgets that would have been revolutionary in their day, including hydraulically powered lifts, dishwashers and cooking spits. Re-introducing one of the most famous, the hydro-electric power generation, has been achieved thanks to a WEG motor/generator installed as part of the new Archimedes screw power installation.

Visitor numbers are steady at Cragside during the day and the Archimedes screw generator is positioned on the main entrance drive, depending on rainfall and supplied by the lake it can run all day when visitors are there and the lake can

Electrical output from the motor is quoted in kVA when it is running in generation mode, so what is desirable here is a high power factor and high efficiency. The WEG W22 unit has both these with a power factor of 0.85 to 0.86 and an output of between 8 and 10 kVA (1kVA is a 1,000 volt amps) which ensures a high degree of the potential energy in the water pushing the screw around as it descends is converted into electricity.

refill during the night if required. Hydro-electricity is popular in some of the other mountainous properties managed by the national Trust where it is more viable as a green power source.

An Archimedes screw generator was chosen because the team was looking for a generator that would work efficiently with a low head of water. An Archimedes design is ideal because it does not require water pressure to operate, just water flow and a head – which is provided by one of the manmade lakes created for exactly this purpose. The lighting for the entire house can now be powered using the flange mounted high efficiency 18.5 kW rated WEG W22 IE3 electric motor.

Robin Wright, Cragside Engineer also shares a passion for all things mechanical, commenting on the installation he said, *"I think he [Lord Armstrong] would be delighted with the new hydro-power installation, he was an innovative thinker and loved anything that used water to make power, he also made comments about coal lasting two hundred years and solar power being something for future generations to exploit, so a bit of a visionary."*

The lighting for the entire house can now be powered using the high efficiency WEG IE3 electric motor driven over-speed as a generator

An Archimedes screw, although ancient in principle, is actually a very efficient way of generating power when you have a large volume or flow of water, but low head

Phil Hall, Sales Engineer from WEG commented, *"We have supplied motor / generator solutions for prominent hydro-power installations in the UK and around the world ranging from ratings of tens of kilowatts to megawatts. In most modern Archimedes screw generator applications there tends to be some inertia within the system – this can be due to the physical size of the screws or the use of a gear reduction stage. Employing a motor is helpful in this instance as the motor can be used to drive the screw until it reaches operational speed and the water flow takes over. Once the water is pushing the screw, then the motor is disconnected from operation as a motor and is mechanically driven over- speed, i.e. over its synchronous speed in order to generate power".*

An Archimedes screw, although ancient in principle, is actually a very efficient way of generating power when you have a large volume or flow of water, but low head.

The lighting for the entire house can now be powered using the high efficiency WEG IE3 electric motor driven over-speed as a generator.

"The system is actually a very efficient way of generating power when you have a larger volume or flow of water but not much space to create a pressure head to drive a mechanical system. The losses are mainly in the gearbox rather than in the motor or the bearings that support the screw, but we need that geared stage to increase the rpm enough to overspeed the motor.

At Cragside the screw drives the 18.5 kW motor at over its 980 rpm synchronous speed via a gearbox, only when the system needs to start-up does the motor draw power to get going. The motor is rated at 93% efficiency so it maximises the available energy conversion from the screw when working as a motor, or a generator".

The W22 motor range from WEG represents affordable energy efficiency; the standard motor which reaches IE3 efficiency levels of 93% is far beyond many other manufacturers' standard product offerings. The W22 range covers frame sizes from IEC 63 to 355A/B and can deliver between 0.12 and 500 kW. For more specialist applications, the W22 range can supplied with increased levels of ingress protection, up to IP66, as well as being specified for operation in potentially explosive atmospheres.

WEG is unusual in that it also offers a full range of super-high efficiency IE4 motors from fractional kW ratings to megawatt powers. These IE3 and IE4 machines, whether used as motors or generators offer an unbeatable combination of high efficiency, range, availability and value.

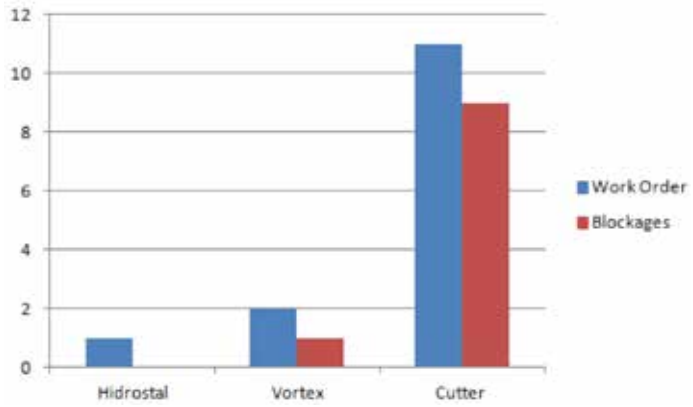
When considering the total cost of ownership (TCO) for a W22 the cost of acquisition typically represents less than 5% of the total cost of ownership over an average operational lifetime. In contrast, the associated energy savings provided by premium efficiency motors far outweigh this additional investment in purchase price, particularly in applications where the process operates on a frequent shift, or 24hr basis.

www.weg.net

Hidrostal Aid Anglian Water at East Coastal Site

Hidrostal Ltd, the UK sales division of the renowned specialist pump manufacturer for the wastewater industry, has provided Anglian Water with a proven solution for a particularly problematic Sewage Treatment Works on the East Anglian Coast.

Corton Church Lane Terminal Pumping Station handles all sewage from the Lowestoft area. The Wet Well Submersible Station had been experiencing a vast reduction in its forward flow capacity due to constant pump blockages at the station.



The regular Planned Maintenance Schedule for the site was no longer sufficient to keep the wet well clean and free of rags. This had resulted in numerous call outs, monthly tankering and wet well cleans just to keep the site operating at its desired capacity. The knock on effect of this was disastrous for Anglian Water's Totex model, resulting in ever increasing energy consumption and a drain on the continuous labour resource at the site.

The installed pumps at Corton Church were of three varying types. The choice of pump had previously been influenced by a range of varying criteria, from solids and rag handling capabilities, free passage, hydraulic efficiency, lowest specific energy, or simply *"just what the original contract stipulated"*. Each of these pumps would vary in their ability to handle rags and cope with the arduous conditions in the well. After numerous pumps, impellers and hydraulic designs had been tested on site, all without success, the Water Utility knew that a solution had to be found without delay.

Following consultations with pump suppliers, Anglian Water decided to run a 3 month trial at the problem site. Hidrostal were selected and delighted to offer their assistance, providing the Utility with a pump incorporating their unique patented single screw centrifugal impeller, which is renowned for its increased free passage capabilities, ensuring that its ability to pump raw unscreened sewage is second to none.

The Hidrostal pump was placed into the wet well along with two of the original

pumps which were retained for comparative purposes. The original pumps were of a vortex design and an adapted cutter type. The pumps were then monitored for a period of 3 months by telemetry systems and the data which was collected helped identify which, how often, and what, contributions each pump made in terms of running time, blockages and energy consumption.

At the end of the trial, following analysis of the data, it was clear that the Hidrostal pump performed to the highest standard overall with no blockages at all during the time period. Furthermore Hidrostal's pump also delivered the added benefit of a reduction in energy consumption.

Anglian Water were so impressed with the benefits of Hidrostal's centrifugal screw impeller that, after a further extended period of operation, the decision was made to change the two remaining pumps in the well to the Hidrostal screw centrifugal impeller design. Since this installation a dramatic reduction has been made in the number of call outs as well as labour costs towards maintenance and a review of the wet well cleaning process which will further reduce the total costs associated with running this particular submersible sewage pumping station.

Lee Barrett, the Maintenance Performance & Standard Engineers for Corton Church was delighted that the ongoing problems at the site have now been resolved. He states *"After concluding the trial the results indicated that Hidrostal provided a more reliable, robust pump which is better suited to sites with high rags/solids content. After testing various pumps of a similar size we were unable to find another pump which could cope with the conditions. The high frequency of failures, ongoing running costs & downtime were simply not sustainable."*

www.hidrostal.co.uk

The Hidrostal pumps incorporating the screw centrifugal impeller on site at Corton Church

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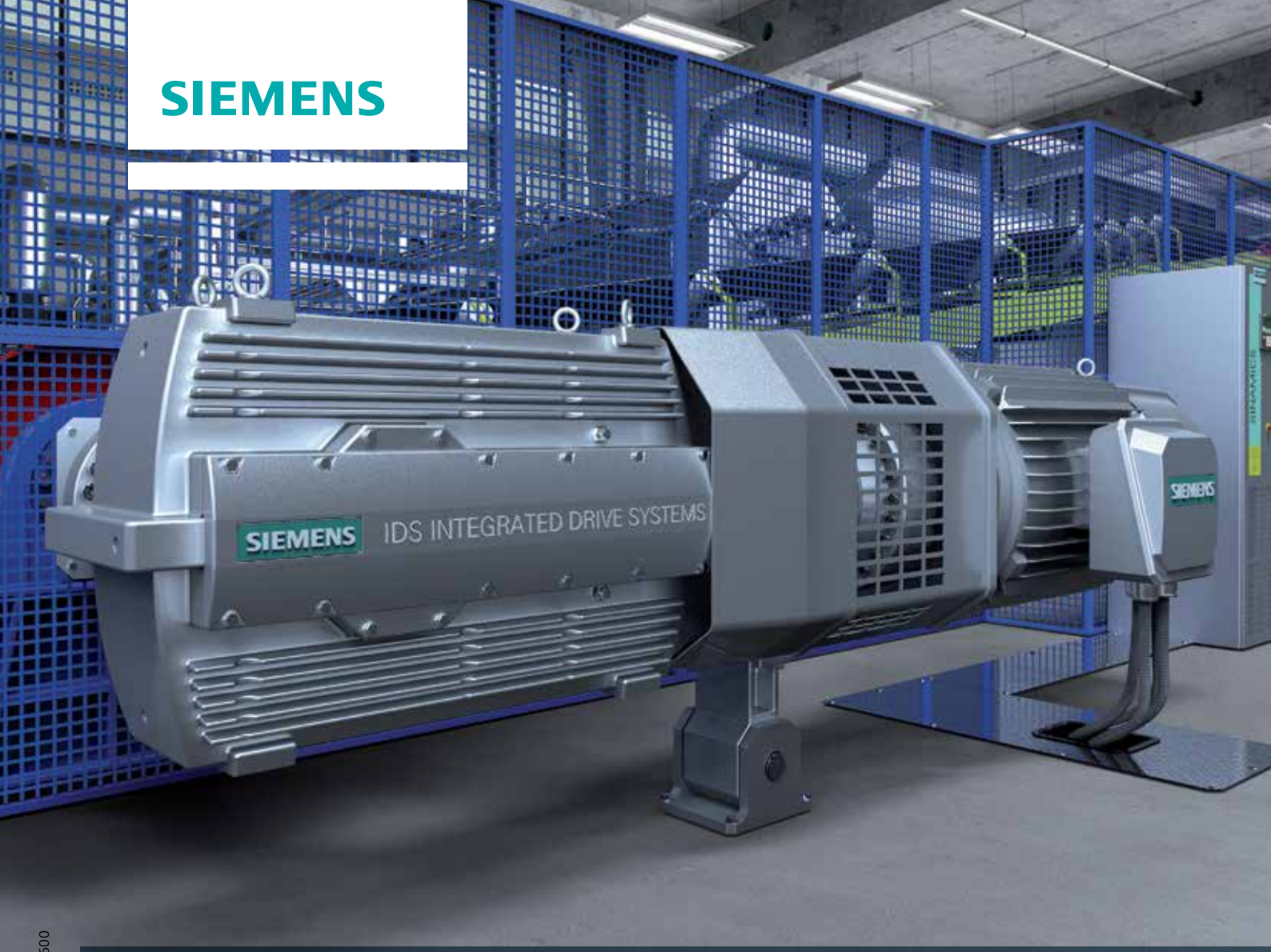

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Screen stars at the Pump Centre

Screening is the first line of defence for treatment works and at the Pump Centre 2016 Jacopa presented the very latest technology in the field. New developments in trash rake technology from renowned manufacturer Bosker® were unveiled including an innovative mechanical grab.

The Company's all new straight through screen (STS) also made its debut on the 'New Product Zone', designed to provide effective protection to downstream assets at wastewater treatment plant inlet works, this high efficiency-low cost unit features easily replaceable screen panels and low cost replacement parts.

Pumps and other critical water and wastewater treatment plant equipment and processes can be badly damaged by debris passing ineffective screens. This disruption is not only an unwanted expense, it can interrupt the smooth running of a treatment plant and is therefore a potential threat to compliance that water companies are keen to avoid.

Managing Director Alex Lloyd said: *"The move to emphasise solutions based on TOTEX means that the industry is looking for robust and effective assets that are easy to refurbish, repair, retrofit and upgrade. This emphasis on 'outcomes' rather than 'outputs' will fuel interest in equipment like the Bosker and our new STS screen that can help meet this aim."*

Grabbing attention

Jacopa's agreement with Bosker gives the wastewater treatment system and service specialist's sole distribution rights to the company's well-regarded water and wastewater screen equipment in the UK and Ireland municipal water markets. Over 1200 of the classic Bosker trash rakes have been installed at power stations, dams, large pumping stations and cooling water intakes around the world and a space-saving version, the 'Bosker Bandit', has been developed for use at smaller pumping stations and inlet works.

Trash rakes are usually installed at water treatment works' river intakes or wastewater treatment works' deep intakes, protecting vital pumps. Conventional versions can require complex civil works and generous amounts of space, and can struggle to remove large, awkward debris such as tree trunks or tyres as well as the fibrous material that wraps itself round coarse screen bars.

The Bosker trash rake is a combination of trash rake, overhead conveyor and debris loading system, which not only cuts costs considerably but also provides a complete solution that works in harmony to dispose of this type of debris. Boskers are pre-programmed with differential level settings, for use in any depth of channel, and can be retrofitted into existing channels with a minimum of modification.

They have proved to be robust, effective tools; the overhead system has a fully automated grab unit whose tough grippers can grasp heavy and awkward items such as plastics, grass, glass bottles, timber, concrete and bricks, as well as balls of condensed fat and rags.

The mobile Bandit is ideally suited to wider inlets, as it is set onto a deck-mounted travel carriage. Both types of Bandit can rotate through 270 degrees to access dumping sites, and like their bigger brothers are fast and easy to install, needing very little construction work. Bosker trash rakes also reduce maintenance and operational costs, in addition to reducing the risk to downstream pumps and other vital equipment.

Jacopa recently won a major contract to protect fine screens and other equipment at Thames Water's massive Deephams wastewater treatment works in Enfield, where a Bosker overhead trash rake system was installed on the high level inlet to replace Rotating Bar Interceptors and bar screens.

At Deephams, two grab units work on a duty/standby basis, cleaning five 11m deep by 2m wide inlets that contain bar screens with 100mm bar spacings. One of the advantages of the overhead system, travelling as it does along a monorail, is that it can be designed so that the trash rake serves a series of treatment works' inlets. At Deephams, the trash rakes remove at least 8 tonnes of debris per hour and can cope with storm flows of over 7000 litres/sec. This installation has an optional wash down system, which sprays wash water onto captured debris to clean it before it is whisked away for disposal.

Jacopa's Key Account Manager Mick Burton says: *"The Bosker units offer many advantages, they are simple to use and install, robust, and very effective. We work closely with our clients to ensure they get a cost effective solution that's optimised for their site, and we're confident that each one will provide extremely high performance debris removal for many years."*

And visitors to the Pump Centre conference were be able to learn about the maker's very latest technology, including an innovative new mechanical grab, from Jacopa's Key Account Manager Mick Burton who presented a breakout session entitled 'Protecting your vital assets' to a packed audience of delegates from across the industry.

A video of the installation at Thames Water's Deephams works can be seen on the Jacopa website at: www.jacopa.com where you can also view the complete presentation made by Mick Burton at the Pump Centre.

Screen Debut

Equipment that can provide effective inlet works protection is in considerable demand, and Jacopa's new straight through screen (STS) has been created with just this in mind. The new screen which made its debut on the Pump Centre 'New Product Zone' has been designed to provide effective protection to downstream assets at wastewater treatment plant inlet works. And with the AMP 6 emphasis on efficiency and customer service in mind, the new STS screen is extremely competitively priced and offers easily replaceable screen panels and low cost replacement screen parts

Jacopa's alternative and highly successful band screens have traditionally provided benefits compared to STS type screens, notably higher screenings capture and no carry-over of screenings to the downstream process. The lightweight Jacopa STS screen is a radical departure from older models, providing a much higher screenings capture ratio, similar to that of band screens with a dramatically reduced risk of screenings carry-over.

The screens can be easily retrofitted into existing inlet channels as well as into new works, or even installed in tanks providing flow can be pumped to them or fed by gravity. The company is also looking at a mobile, tank-based solution for rental. Managing Director Alex Lloyd said: *"We see it as a potential opportunity. We provide a lot of mobile SAF units; obviously the screens would be installed on a very temporary basis to solve urgent problems, but we believe there is potential to help our clients by having this as an option."*

The STS screens have been through rigorous testing at the independently run National Test Centre in Chester-le-Street The tests proved that the screens have a remarkable 81% capture ratio, which means the solution is comparable to the very best of its competitors. And not only has the screen conclusively proved its effectiveness, it is also sets a new industry standard for cost effective service and maintenance.

The unique modular design of the panels, which are fabricated in 9mm thick moulded plastic and set in stainless or carbon steel frames, provides several advantages. Panels can be made with perforations of 3, 5, 8 or 10mm, providing options from very fine to coarse screening. The standard inlet works configuration for fine screening is 6mm, so the moulded units provide a useful improvement whose design should also help with the perennial problem of excluding cotton bud sticks.

A patented deep, tapered hole system also ends the common problem of hair pinning; standard steel panels are just 2 to 3mm thick so fibres can easily become trapped across two apertures, whereas the depth of the Jacopa panels prevents this problem.

The ease of cleaning impressed onlookers, there is no cleaning brush to adjust or replace, as the design means only a washwater spray cleaning system is required providing both energy and maintenance savings. And to guarantee simple operation and maintenance, the screens have been engineered not to require chains.

For smaller sites that may only have one channel and a single screen, a solution that minimises downtime is extremely attractive. Another maintenance benefit is that the drive mechanism is at the top, out of the water. Only the screen curtain itself and its guide track (rather than a sprocket drive) enter the water. There are no other parts below water; everything else is accessed at coping level.

The modular construction enables the units to be manufactured in 150mm increments from 450mm to 2000mm wide, to cover a wide range of flows (from 50 to 1000 litres sec) and channel widths (500mm to 2000mm). The screens can be installed at steeper-than-normal angles of 45 or 65 degrees in the channel to improve flows, and the single drive unit contributes to ensuring low running costs.

In normal use, the STS is a classic escalator-type fine screen. Jacopa's emphasis on modularity and standardisation significantly reduces downtime. Normally, if a screen is damaged, the whole panel length has to be replaced. With the modular STS screen, a single panel can be quickly and easily slotted in, providing significant savings in terms of components, labour, and downtime.

The standardisation also means that manufacturing and delivery times are reduced. Jacopa's engineers use advanced 3D graphics and modelling packages to design screens and associated equipment efficiently and precisely to suit site conditions. The screen also has the advantage of being BIM-compliant, Alex Lloyd explains. *"We have ensured that the STS screen is ready for the BIM standard, and all of the relevant information is available if required."*

The STS screen is initially being launched into the UK and Ireland municipal market where they join Jacopa's 'triad' of product types including Screens, Screen Handling and Transfer equipment to provide customers with a comprehensive inlet works package.

Alex Lloyd says: *"We are very pleased that we now have a highly competitive offering that provides a robust and comprehensive inlet works solution, which is what our customers want. We thoroughly enjoyed welcoming visitors to the Pump Centre on our stand, and to presenting these exciting new developments for both the Bosker trash rakes and the STS screens."*

www.jacopa.com

A life cycle approach to pump system reliability

Variable-speed drives are an integral part of many of today's pumping applications, so keeping them reliable is essential. With AMP6 taking a total expenditure approach, we look at ways to keep drives operational and their costs down.

In today's water industry, pumps are often combined with flow control and measurement equipment as part of a complete pumping system.

Keeping the costs of these pumping systems in check while serving customers consistently is a major concern for water companies. The total expenditure - or Totex - approach to system costs is a major plank of AMP6, and considers not just the purchase costs of the components but their running costs and also the cost of not running. In the water industry the costs of NOT running can take the form of environmental issues, fines, downtime and disruption to customers. This makes keeping the pump system reliable extremely important.

When it comes to running costs, the way water flows are controlled has a major effect. A common approach is to use a throttling valve. This is very inefficient as pumping water against partially closed valves wastes a lot of energy.

To alleviate this problem, electronic variable-speed drives (VSDs) are increasingly common. Particularly useful in parallel pumping applications or those with a changing demand, drives can bring significant energy savings by matching motor speed to the demand of the process.

Using a throttling valve can also cause premature pump failure, so eliminating it can improve pump reliability.

Drives improve pumping station's reliability

An example of how drives can contribute to the overall reliability of a pumping system is Susworth Pumping Station, which uses two submersible pumps to transfer surface water into the River Trent. The pumps are rated at 65 kW and 75 kW, with a combined full load current of 202 A. Both pumps run at 950 rpm.

The pumping station's electrical supply is via a 100 kVA transformer. This rating allowed only one pump to run at a time.

The solution was to use drives to run pump one at 41 Hz, drawing 38 kW, with pump two running at 37.5 Hz, drawing 28 kW. This means that both pumps now run at 80 percent capacity, with 29 A in hand over the full load current for both pumps.

The pumps are expected to save between 10 and 15 percent on their energy use.

Running at this capacity means that the transformer is not overloaded and together the two pumps achieve a higher pumping volume than one pump at full rate.

Because the pumps can be run simultaneously, the pumping system is more reliable and sharing the load between them avoids the need for a costly transformer.

With lower speeds and soft starts, the drives place less stress on the motors, helping reduce wear.

Maximising a drive's reliability

Maintenance plays a large part in maximising the reliability of drives. Poor or even non-existent maintenance of drives will lead to failure. Examples include inadequate inspection or cleaning.

To decrease the probability of electronic components failing, drives may have to operate in a well air-conditioned room, where temperature, humidity and air pollution are controlled. Drives also need to be kept dry to avoid corrosion.

A whole life approach

Although good maintenance is essential to keeping a pump system's drives in operation, it is also important to understand what is happening to a drive over its lifetime and create a maintenance regime to suit.

Drives go through four life phases - Active, Classic, Limited and Obsolete. The Active phase is the sales and manufacturing phase, following which the product moves into the Classic phase. In the classic phase, new drive hardware and software development may be required to guarantee that the drive continues to

operate at its peak performance. These phases offer complete lifecycle support.

In the Limited phase, product support is reduced, ending in the Obsolete phase where the product is no longer supported.

To manage drives and maximise their reliability, you need to know which phase they are in, to determine what support is available to keep them running.

You also need to know their history, maintenance regime and how critical they are to production or safety, to assess what level of effort and resources are needed to maintain them.

Getting to know your drives

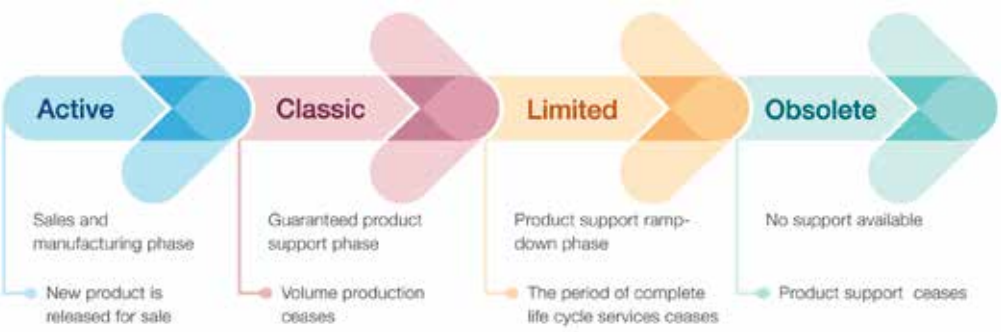
Achieving this complete picture is the aim of a life cycle assessment (LCA). This is an investigation into all drives used in your pumping applications – how old they are and what life cycle stage they are in, where they are used, how critical they are to their processes and how well and how often they have been maintained. This information forms the basis of a maintenance plan to help you make the most of your drives and make the best investments if you need to replace them.

By assessing where each drive is in its life cycle and its condition, the LCA ensures that each drive gets the attention and maintenance it needs to prolong its life and avoid premature failure and also helps life cycle planning.

The first stage is to collect all applicable data about installed drives. This will list all the drives and show details such as life cycle stage, location, protection class, when they were commissioned, the application they are used on and the date of their last maintenance.

This process will also identify how critical each drive is to the operation of the process. This is based on criteria such as business impact, maintenance history and operating conditions which may increase risk of failure.

Drives assessed as having the top level of criticality need special attention as they are running applications that are critical or highly critical. These could include maintaining pressure in domestic water mains, which water companies are required by Ofwat to maintain at seven meters static head pressure. Failure could mean a water company paying compensation to affected customers. These applications could also have a high danger of failure due to the conditions they operate in.



The next criticality level is drives running critical applications or whose probability of failure has increased.

The lowest level of criticality is drives that are not running critical applications or which are operating in good environmental conditions. Assessing the criticality of each and every drive helps develop the best bespoke maintenance plan for each unit.

Managing your drives

Once the exact condition of the drives is known, a lifecycle management plan can be drawn up to manage maintenance, migration and obsolescence. This plan implements recommendations from the life cycle audit, developing preventive maintenance schedules for each drive and implementing appropriate predictive maintenance.

This programme will recommend exactly which drive needs what level of attention – either replacement, upgrade/ refurbishment, a major preventive maintenance action or a basic preventive maintenance action. This plan ensures the right resource and investments can be provided at the right time.

For example, it may state that a particular drive has not been maintained and is in a Criticality 1 area. The plan will recommend that this drive needs urgent maintenance to keep the process running.

Taking a whole life approach to drive servicing and replacement means that drives are kept in service longer, costs are reduced – one of the major goals of AMP6 – and water companies can continue to meet their obligations to the public in a cost-effective way.

For more information and advice about improving reliability in the water and wastewater industry, visit ABB's dedicated Reliability portal at: bit.ly/ABB_TOTEX_Reliability

www.abb.com

Training & Awareness Day Programme 2016

Featured events:

Scottish Mini Conference
6th October 2016 at the Best Western Garfield Hotel, Stepps, Glasgow

The theme of this year's Scottish Conference is TOTEX in the Water Industry. The aim is to provide an introduction to the concept of TOTEX and illustrate its use via some case studies. The technical agenda will consist of four sessions which will develop the benefits of the TOTEX approach which aims to deliver long-term value-for-money incorporating both CAPEX and OPEX. The event will be supported by 20 exhibitors who will promote a range of products and services

Pumps and Pumping Systems for Non Engineers

This training course is intended for those who are not Engineers or technically minded but need to know more about pumps due to the nature of their work. Those working in the Finance department of a company dealing with pumps and / or pump spare parts, for example, who are responsible for carrying out a stock take of pump parts but are not familiar with pumps may benefit from the course. Others dealing with Engineers or Technicians who work on pumps and need to understand the terms used when scheduling their work, dealing with enquiries or ordering spare parts may also benefit from this course.

No technical knowledge or prior experience with pumps is required as the course is designed for non-technical people. Layman's language will be used at the outset to build and develop an understanding of pumps and pump components.

Sewage Pumping Station Design

This one day course will cover the essential requirements for designing Sewage Pumping Stations. The design of sewage pumping stations provides unique challenges in addition to those normally encountered in the water industry. The course will begin by covering the general requirements for pumping station design including liquid properties, different types of pumps & their characteristics, system curves, selecting the right pump for the system and cavitation. All topics will have an emphasis on sewage pumping design aspects. The course will continue to provide more detailed coverage to the requirements for sewage pumping stations including sump design, how to mitigate solids deposition, generating system curves at site, design and operation of dry and wet wells and duty/assist/standby pumping. The course is intended to provide those who are required to design pumping stations, approve designs submitted by others or advise on possible improvements to existing systems with the skills they need.

For more details contact Jim Eaves, email jim.eaves@arcadis.com or call 07968 707753

Title	Date	Full Price	Members Price
Pumps & Pumping Systems for Non-Engineers (Reading)	6 Sep	£350 + VAT	£245 + VAT
Sewage Pumping Station Design (Reading)	13 Sep	£350 + VAT	£245 + VAT
Pumps & Pumping Systems – Introduction, Intermediates & Advanced (Warrington)	13 – 15 Sep	£795 + VAT	£556 + VAT
Pumps & Pumping Systems – Introduction (Warrington)	13 Sep	£350 + VAT	£245 + VAT
Pumps & Pumping Systems – Intermediates (Warrington)	14 Sep	£350 + VAT	£245 + VAT
Pumps & Pumping Systems – Advanced (Warrington)	15 Sep	£350 + VAT	£245 + VAT
Effective Presentation Skills (Reading)	20 Sep	£350 + VAT	£245 + VAT
Sewage Pumping Station Design (Warrington)	20 Sep	£350 + VAT	£245 + VAT
Maintenance of Rolling Element Bearings (Warrington)	27 Sep	£350 + VAT	£245 + VAT
Improving Pump Maintenance (Warrington)	28 Sep	£350 + VAT	£245 + VAT
Why Mechanical Seals Fail (Warrington)	29 Sep	£350 + VAT	£245 + VAT
Scottish Mini Conference	6 Oct	£120 + VAT	£96 + VAT
Waste Water Screening & Preliminary Treatment (Warrington)	12 Oct	£350 + VAT	£245 + VAT
Pumping in the Water Industry 4.5 days (Warrington)	17 – 21 Oct	£995 + VAT	£696 + VAT
Pumps & Pumping Systems – Introduction, Intermediates & Advanced (Reading)	1 – 3 Nov	£795 + VAT	£556 + VAT
Pumps & Pumping Systems – Introduction (Reading)	1 Nov	£350 + VAT	£245 + VAT
Pumps & Pumping Systems – Intermediates (Reading)	2 Nov	£350 + VAT	£245 + VAT
Pumps & Pumping Systems – Advanced (Reading)	3 Nov	£350 + VAT	£245 + VAT
Social Media (Warrington)	8 Nov	£120 + VAT	£96 + VAT
Principles of Electric Motors, and Drives (Reading)	9 Nov	£350 + VAT	£245 + VAT
Pumps & Pumping Systems for Non-Engineers (Warrington)	10 Nov	£350 + VAT	£245 + VAT
Introduction to the Water Treatment Process (Reading)	30 Nov	£350 + VAT	£245 + VAT
Introduction to the Sewage Treatment Process (Reading)	1 Dec	£350 + VAT	£245 + VAT
Introduction to Valves (Warrington)	6 Dec	£350 + VAT	£245 + VAT

(Awareness Days are highlighted in red).

Pump Centre members receive 30% discount off training courses and 20% discount off awareness days

All courses (unless indicated) will be held at:

- Reading courses will be held at:
  Best Western Calcot Hotel, Reading RG31 7QN
- Warrington courses will be held at:
  The Lymm Hotel, Warrington, Cheshire WA13 9AQ

The majority of our training courses can be run *"In-House"* at a venue selected by the Client. In-house courses become cost effective when clients have 8 or more members of staff to be trained. Please contact the Pump Centre for a quote.

To discuss your training requirements contact:
Jim Eaves: 07968 707753 or email jim.eaves@arcadis.com

To reserve your places contact:
Karen Bridgeman: 01925 843512 or email karen.bridgeman@arcadis.com

For more training information visit www.pumpcentre.com

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