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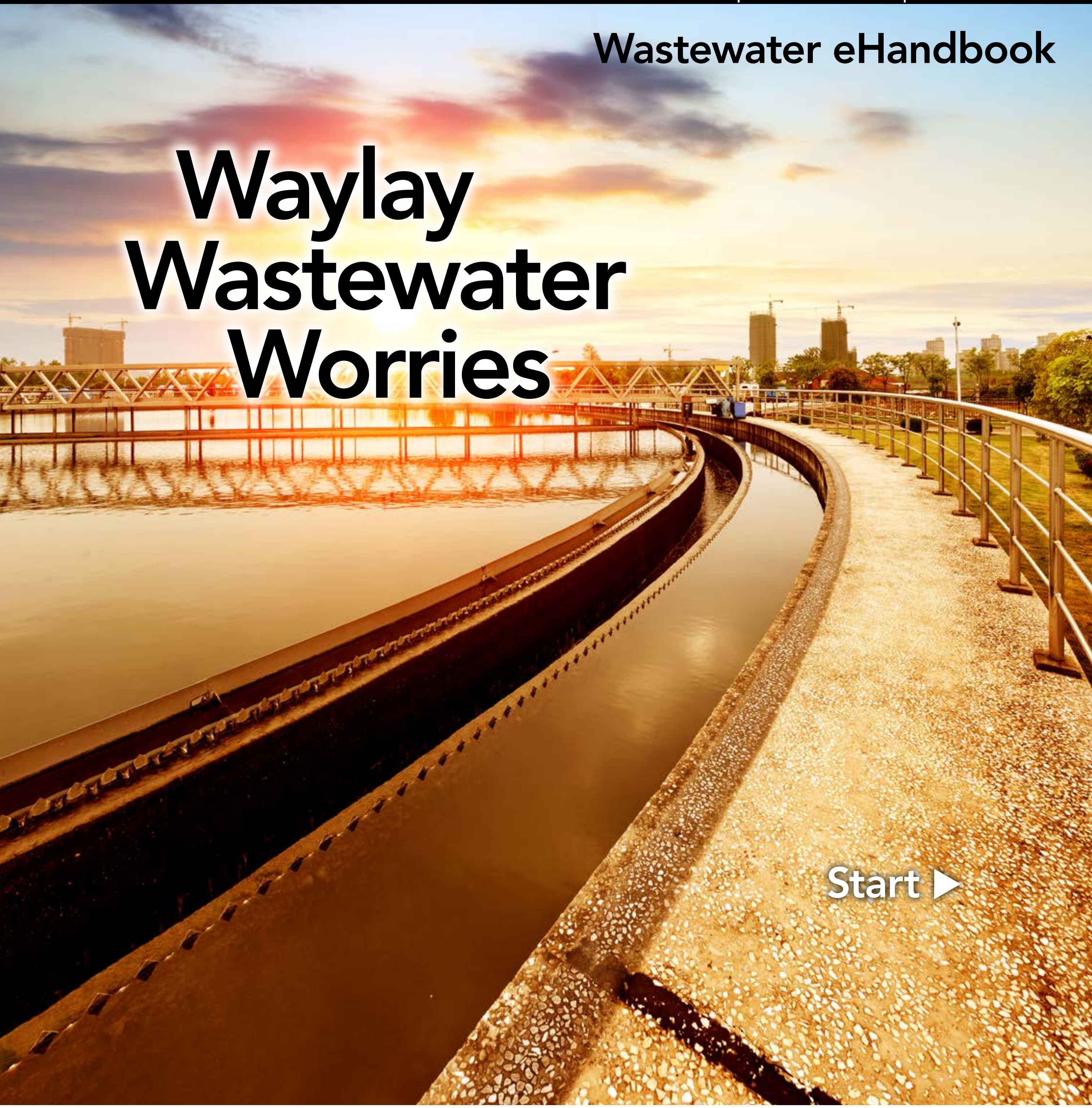

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Water Worries Aren't Dampening

Latest CDP report underscores the continuing risks companies face

By Mark Rosenzweig, Editor in Chief

THE CARBON Disclosure Project (CDP), London, has released its Global Water Report 2014. The CDP, which compiles the report on behalf of 573 investors with $60 trillion in assets, asked more than 2,200 companies around the world — double the number queried in 2013 — to provide information related to water. It received 1,064 responses, an increase of 79% from last year. The report focuses particularly on the inputs from firms on the Financial Times Global 500. The CDP sent requests for information to 302 of these companies, the ones in sectors highly vulnerable to challenges posed by water issues. A total of 174 (58%) of the firms responded.

"Leading companies increasingly recognize that business-as-usual approaches to water management are no longer sufficient. A shift in practice is required if companies are to realize the true benefits of water stewardship, achieve business resilience and competitive advantage," notes Paul Simpson, CEO of the CDP, in the report.

Two-thirds (68%) of respondents stated that water poses a substantive risk to their business. Moreover, nearly a quarter (22%) said water-related issues could limit the growth of their business. One third of these respondents expected to face such a constraint in the next 12 months.

The top driver of risk is water stress or scarcity, which was cited by 43% of respondents; 28% mentioned flooding, 16% drought, 14% declining water quality and 13% regulatory uncertainty.

Only 38% of respondents said they evaluated water risks in both their own operations and their supply chain. 60% admitted they don't require key suppliers to disclose the water risks they face.

The CDP report breaks down responses by group; chemical companies are in its "Materials" group, and accounted for half of the 22 responses

in that group. The response rate of chemical firms (79%) was among the highest in the survey. Chemical companies that provided information include BASF, Bayer and DuPont.

Key findings for the group included:

- 45% of respondents have suffered negative impacts related to water in the last reporting year, a percentage far higher than the average of all respondents (30%), and the second highest of all sectors.
- 32% have conducted a thorough water risk assessment incorporating both direct operations and supply chain.
- 86% have established specific water targets or goals this year.
- 64% said that water risks impacted their operations, while 23% foresaw such risks in their supply chains.
- 32% required suppliers to report on water.
- 64% noted that water commands board-level oversight.

A majority of chemical industry respondents (54%) pointed to physical issues such as water scarcity as the top driver for risk; 33% cited regulatory concerns such greater difficulty in getting operating permits; and 7% mentioned potential damage to their company's reputation.

Many also expected water concerns to provide opportunities: 45% foresee sales of new products and services; 41% hope to realize cost savings; and 27% expect enhanced brand value.

The CDP Global Water Report 2014 is downloadable via http://goo.gl/5iPFGb. For details on the findings in earlier CDP Water Reports, see "The Tide is Turning," http://goo.gl/Y68uUb, and "CDP Releases Second Annual Water Report," http://goo.gl/pLrJAi.

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Don't Waste Energy with Wastewater

Simple monitoring actions and adopting best practices may lead to significant savings

By Ven V. Venkatesan, Energy Columnist

IN MOST chemical processing plants the primary objectives of wastewater treatment plants (WTPs) are to meet regulatory requirements and protect public health. Rising energy costs are placing a greater financial burden on wastewater treatment and discharge. Improving energy efficiency at WTPs could help control overall energy costs.

Energy efficiency and protecting the environment are not mutually exclusive. In most plants, energy conservation programs not only reduce energy usage at the facility, but also provide improved control and operation of their unit treatment processes. Hence, this column covers a few tips about controlling and sustaining energy costs in a plant's wastewater treatment operations.

Most water/wastewater utilities need to operate, maintaining the wastewater discharge specifications, while improving their energy efficiency and managing their total energy consumption. The above goals consider both the costs associated with energy use and the plant's reliability over time. With a better energy-management plan and adopting best practices, these goals can be balanced to avoid unanticipated costs, and still improve overall energy efficiency. WTPs also can have energy benchmarks such as gallons of water treated per kilowatt-hour of electricity consumed or kwh/mgd. Some plants are able to sell their treated wastewater back to local communities for domestic use other than potable water. Some communities have separate water service for garden and farm-land irrigation from their neighborhood WTP. A petroleum refinery in southern India recycles 100% of its treated wastewater, saving substantially on its overall utility cost. In addition, due to scarce fresh water, better wastewater treatment and reuse helped the refinery to operate without straining the local authority's water supply system.

Improving overall efficiency of WTPs begins with simple monitoring actions such as leak detection, repairing the water distribution system, or reducing infiltration and inflow to wastewater collection systems.

Water/wastewater treatment is energy intensive mainly due to pumps and electric motors moving large volumes of water. The cost of electricity used in the treatment process is based on two main

components: the quantity of electricity used and the peak demand reached in using the electricity. Because the objective of energy cost control is to minimize the facility's overall electricity bill, peak demand reduction is a potential energy cost control opportunity applicable to wastewater treatment. Strategies to lower peak demand include monitoring and addressing the infiltration and inflow, providing additional water storage tanks to flatten pumping demands during peak periods and shifting non-critical loads to off-peak periods, and flattening demand by minimizing the overlap between treatment processes. Considering the sequence of backwash cycles and off-peak backwash times is a common non-critical operation that also can help reduce electric demand.

Reducing the total number of kWh required to treat a given volume of water or wastewater also cuts down the electricity bill. The amount of energy used for water/wastewater treatment consists of various factors, including: treatment unit's capacity, treatment process, type and condition of equipment, and operation and maintenance (O&M) practices. The topography of the WTP also could contribute to higher pumping costs.

In some wastewater treatment units several low- or no-cost opportunities may exist, such as operating only the required level of aeration tanks, installing control equipment based on dissolved oxygen monitoring, idling an aeration tank during low-flow periods, and reducing air flow to the aeration tanks during low-load periods. Regularly cleaning UV lamps is another simple O&M improvement, because lamp sleeve fouling affects equipment performance.

Closely matching pump and motor size to demand also can improve energy efficiency. Most WTPs are designed with excess pumping capacity to cater to peak demands and growth expectations. However, the actual wastewater inflows are lower, due to normal plant operational levels, and conservation efforts at the source units. Hence, if pumps are found operating far from their optimal efficiency point, their energy consumption levels would be higher. If pumps routinely operate outside of their design point for efficiency, then a new pumping solution, such as installing variable speed drives, may reduce energy costs.

In some wastewater treatment units with anaerobic digesters, routing the digester gas to the hot water boilers or using the digester gas to generate electricity using a microturbine can help reduce energy costs. Some microturbines can run on digester gas or biogas from WTPs. It's also worthwhile to assess the feasibility of implementing fine bubble aeration at activated sludge treatment facilities, as well as considering supercritical oxidation of wastewater sludge. ●

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Water Conservation Efforts Pay Off

Multifaceted worldwide initiative significantly reduces consumption

By Julie O'Brien, Air Products

THE OLD adage what gets measured gets managed is a concept that is particularly true for water consumption at Air Products, Allentown, Pa.

Air Products consumes approximately 15 billion gallons of water each year at our facilities worldwide. We annually survey plants on water use as well as other environmental measures, and compare the results year-on-year to our environmental sustainability goals. The water data include intakes by source, discharges by destination, production volumes and contaminants (where collected). We then calculate consumption as intakes less discharges to the same source. For example, water that comes from and returns to a specific water body is not counted as consumption. This is particularly relevant to Air Products because much of the water we use is for plant cooling and goes back to the original source.

To evaluate performance against the company's water goal, we subtract from the consumption the water required as a reactant or exported; this value is normalized by production so the results can be compared on an intensity basis.

In 2009, when Air Products engineers began centrally collecting water consumption data for more than 200 of our global facilities, opportunities to reduce water use quickly came to light. For example, by comparing expected and actual water use per unit production, we discovered leaking pipes at some older facilities; these were promptly repaired.

That same year, the company set a goal to cut consumption of controllable water — which excludes water used as a reactant or exported to customers as steam or water — on an indexed basis by 10% by 2015. Through plant efficiency improvements, facility-level assessments and use of recycled water, we met this water reduction goal four years ahead of schedule.

IMPROVING PROCESS EFFICIENCY

The manufacture of hydrogen via steam methane reforming (SMR) accounts for more than half the water Air Products consumes each year. In the SMR process, water is used in two steps: to reform the methane to carbon monoxide and hydrogen, and then to shift the carbon monoxide to carbon dioxide. On a stoichiometric basis, 0.55 gallons of water are needed to make each pound of hydrogen.

Because the SMR reaction is exothermic, water also is required for cooling. The cooling towers at our plants have varying levels of efficiency and water loss as well as different discharge requirements. Overall water consumption for hydrogen production through SMR, including water used for in-plant cooling, is approximately 4.1–5.5 gallons per pound of hydrogen produced, based on data from the U.S. Dept. of Energy's Lawrence Livermore National Laboratory [1].

SMR exemplifies the "water-energy nexus"— water is required to make hydrogen, which in turn is used to remove sulfur from crude oil to

Figure 2. Facility in drought-plagued area of California has replaced potable water with recycled water in its cooling tower.

produce cleaner-burning fuels. Air Products' energy efficiency, greenhouse gas emissions and water goals are all related through this nexus. Using a 2007 baseline, the company has set goals to both increase energy efficiency and reduce greenhouse gas emissions by 7% on an intensity basis at hydrogen/syngas (HyCO) and air separation facilities by 2015. By improving energy efficiency, our water consumption and greenhouse gas emissions will decrease on an intensity basis. We have made progress on all these goals, including cutting the amount of energy consumed per unit production at hydrogen facilities, resulting in lower water consumption on an intensity basis.

Another significant portion of the water consumed by Air Products each year goes for cooling air separation units (ASUs). In these facilities, air is compressed so cryogenic distillation then can fractionate nitrogen, oxygen and argon; in many cases, additional compression is used to liquefy products. This compression generates a significant amount of heat that is removed through water-cooled heat exchangers, necessitating cooling towers at each ASU. As at the hydrogen facilities, our engineers have improved the energy efficiency of the ASUs and brought new, more-efficient plants online, thus decreasing the company's water consumption.

We also have initiated a series of plant-level water use reviews at representative facilities around the world. Done in conjunction with GE Water, these "water assessments" bring personnel from the

two companies together to evaluate plant operations to identify opportunities to save water and reduce costs. During the assessment process, the team tours the plant, confirms piping and water flows, and pinpoints specific projects that can cut water consumption. By the end of the assessment, the team has come up with a list of recommended projects along with their estimated costs and benefits so Air Products can determine the next steps and develop action plans.

Through this program we have assessed most of our major HyCO and ASU facilities, including plants in the U.S., Canada, Brazil, the United Kingdom, Poland, Spain, the Netherlands, China, Korea and Taiwan. The assessment teams have identified ways to save on average 5–10% of the water being used at these plants. Recommendations for reducing water consumption typically include increasing cooling tower cycles, optimizing water pretreatment systems, capturing condensates and reject water from treatment processes, and recycling water. We share the results of these assessments company-wide through our plant process engineering organization so similar facilities can benefit from the opportunities identified.

Our work with GE Water builds on the two companies' long-standing efforts to decrease costs associated with water use and treatment. For many years, GE Water has been our primary provider of water treatment services and chemicals and has had annual incentives to reduce consumption and costs. Through process improvement projects identified and implemented jointly by the companies, Air Products has saved millions of gallons of water and millions of dollars in associated water and treatment costs.

PRIORITIZING PLANT ASSESSMENTS

Members of Air Products' water team spearhead the assessments and closely monitor water consumption. This team consists of representatives from our operations, environmental, procurement and sustainability groups and includes a GE Water representative. Most recently, the water team used geographical information system (GIS) mapping to evaluate our facilities based on the risk of water stress.

The team mapped water consumption for Air Products' global production facilities against data from the Aqueduct database of the World Resource Institute (WRI). The visual tool, which took the form of a GIS map, integrated water consumption at our facilities with WRI data on drought severity, baseline water stress, groundwater stress and other water-related factors. Circles represent our facilities, with circle size indicating a plant's absolute consumption of water (Figure 1). Color-coding shows the relative consumption on a unit-of-production basis as a percentage of water available. By looking at this map, the water team quickly could identify those facilities in water-stressed areas that were consuming a large or disproportionate amount of water. These sites were recommended for further evaluation and water assessments based on water stress and consumption.

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USING RECYCLED WATER

Air Products operates about 20% of its facilities in water-stressed areas and looks for alternative water sources for these plants. For example, the management team at our facility in Santa Clara, Calif., learning of a potential source of recycled water that could replace potable water in the cooling tower, saw a great opportunity to reduce operating costs and help with environmental and public concerns in a drought-ridden part of California. The plant now saves 62 million gallons of potable water every year by using recycled water (Figure 2). In addition, the cost of the recycled water is less than that of fresh water, enabling the plant to cut water expenses by about half. These results have provided an incentive for the City of Santa Clara to expand its recycled water infrastructure for other consumers.

Air Products pursued a similar opportunity at another California facility. By teaming up with the Central Basin Municipal Water District, the wholesale supplier of water for 23 cities in Los Angeles County, engineers at our Santa Fe Springs ASU plant replaced 73 million gallons of potable water used in the site's cooling tower each year with recycled water. This approach put 225 acre-feet of potable water back into the community's water supply — enough to supply hundreds of families.

The use of recycled water also was a key consideration in the water assessment completed for our hydrogen plants in Edmonton, Alberta. The SMR units there use recycled water from the local municipality. The water entering the plant is of low quality but reliable operation of the boilers that generate steam for the SMR shift reactions demands very high quality water. Therefore, the boiler feedwater (BFW) must be treated to prevent scale formation, silica volatilization and condensation, and corrosion in the boiler. Treatment also is required to remove particulate matter.

BFW treatment occurs in two steps: the water is dosed with chemicals and treated using reverse osmosis (RO) to remove most of the ions, and then the product water from the RO system is polished via ion exchange using a salt solution. Approximately 30% of the raw water purchased is discharged as wastewater that consists of RO reject and process waste.

When the water assessment team at Edmonton met to identify opportunities to cut water consumption and water-related operating costs, its primary focus was on managing the quality of the incoming water. As a result, most of the opportunities the team identified focused on reducing or re-using the RO reject water. Suggestions included adding a scavenger to the RO phase and finding alternative uses for the reject water. The team also recommended improving the water treatment system by optimizing chemical feed points, installing a bulk chemical system and automating chemical injection for water treatment. Additional studies were proposed, including optimizing RO recovery, improving microbiological control and modifying the plant's supply chain for water supply and export. Since the water assessment was conducted, water consumption at Edmonton has decreased by 12% on an intensity basis.

These programs to reduce water consumption, as well as those aimed at improving the efficiency of our use of other resources, are part of the company's risk management efforts. Air Products recognizes that major changes are underway with respect to

resource use and availability; as the world's population increases, so will competition for these key materials. In fact, the World Bank predicts a 40% global shortfall of water by 2030, which likely will impact water availability and costs.

PREPARING FOR THE FUTURE

Water availability represents an operational risk to us because our facilities can't operate without this resource. As a result, the company's enterprise risk management process explicitly considers water. In this process, subject matter experts and stakeholders most affected by the particular risks annually review four categories of risks — business operations, strategic planning/technology, financial controls, and legal/regulatory/governance.

A corporate compliance and risk committee provides senior-level oversight to the process, helping shape the risks to be considered and ensuring ongoing periodic review of high-profile risk elements. The chief risk officer has accountability for identifying and cataloging all relevant business risks and shares responsibility for water and other environmental factors with managers specifically charged with overseeing those elements.

Our corporate risk office also administers a country risk assessment process, which evaluates a portfolio of operational and strategic risks of entry into a new country. It uses information from Verisk Maplecroft, particularly the "Global Risk and Resilience Atlas" and "Resource Security Index," which includes water quality and stress. Water availability also is evaluated when siting new facilities.

Also as part of our enterprise risk management program, we routinely assess the risks of new operations — from grassroots projects to expansions of existing facilities. The company considers biodiversity, land use and ecosystem impacts, and evaluates a project's potential impact on wildlife, vegetation and habitat (particularly wetlands). This assessment can influence decisions to modify the project or develop mitigation to ensure the ecological health of the region is maintained or enhanced.

Our water center of excellence (COE) follows emerging water issues. Comprised of environmental subject matter experts, the COE tracks developments in water permitting, protection and quality; most recently it has been following water curtailments in drought-stricken areas. The COE also engages with stakeholders to proactively identify water-use-reduction opportunities and sourcing strategies to avoid potential conflicts.

Air Products takes its responsibility to manage water resources in a sustainable manner very seriously. Through plant assessments, efficiency improvements and increased recycling, we have cut the amount of water needed to manufacture our products, reducing water intensity by 24% over the last four years. ●

JULIE O'BRIEN is sustainability director for Air Products, Allentown, Pa. Email her at obrienjk@airproducts.com.

REFERENCE

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WATER & PROCESS SOLUTIONS

Handle More Flow

Success often depends upon lowering head losses or raising pump pressure

By Andrew Sloley, Contributing Editor

STRAIGHTFORWARD HYDRAULIC systems follow simple rules. For non-Newtonian and incompressible fluids, flow and net pressure drop are directly related. Consider the water transfer system shown in Figure 1. Wastewater generated in Unit 1 is stored in tank T1. Some of the water is reused in Unit 2. The remaining wastewater goes to treatment via vessel V1 in Unit 2. When Unit 2 isn't running, centrifugal pump P1 provides the head for transferring the water from tank T1 to vessel V1.

Plant management wants to increase the average water rate by 20%. Equipment elevations must remain the same, as must upstream or downstream process conditions. Because the system has simple hydraulics, providing more flow requires some combination of reduced head losses in the system or increased pressure generated by pump P1.

The control valves balance the pump performance curve against the system curve. As long as the control valves can open and the flow rate is within the pump's capability, more flow is possible.

In this case, with the control valves wide open, the new flow rate can't be achieved. Even with modifications the system is in a gray area. Some simple modifications may — or may not — allow the desired flow rate.

Already identified modifications include:

- moving exchangers E1/E2 into parallel; and
- replacing orifice flow elements FE1 and FE2.

Plant management must accept some combination of:

- lower flow;
- removal of more pressure drop; or
- increase in head available.

The solution may include all or any combination of these steps. Let's look at the flow scheme and then examine each area in turn.

The system has a fixed static head loss. Because the equipment and process don't change, the static losses don't either. The entire pressure-drop reduction must come from cuts in dynamic head losses. Three components — the exchangers E1/2, the control elements and the piping — mainly contribute to the dynamic head losses.

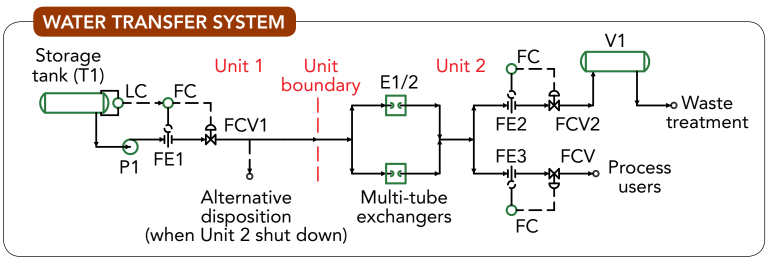

Figure 1. Plant management wants to increase the average water flow rate by 20%.

Exchangers E1/2 originally were in series. At the higher flow rate, the units will operate in parallel.

They are multi-tube exchangers with the inlet water on the tube side. Unless they are completely replaced, the exchangers now have a minimum pressure drop.

The control elements include two orifice flow elements plus two control valves. The modifications already include replacing both flow elements. Changing the orifice plates saves 13.2 psi of pressure drop. At the desired rate, the two new flow elements will have a combined pressure drop of 5.1 psi.

After the modifications are made and with the existing pump, if it performs per the manufacturer's performance curve, the system can meet the required flow rate with control valves FCV1 72% open and FCV2 80% open.

To provide the best control, good operating practice suggests having FCV1 and FCV2 operate between 25% and 75% open. The new maximum rate has FCV1 just within the good practice range and FCV2 just outside that range. However, little control flexibility is available to handle temporary excursions to higher rates.

The second question is pump performance. The hydraulic analysis assumes the pump operates on its performance curve. Pump performance often deviates from that curve. After long in-service time, delivered pump head may differ by up to 10% from that shown on the performance curve.

The system with the base modifications can't effectively handle higher rate excursions above the average value nor could it run at the desired rate if the pump operates with heads below those documented on the pump curves. Increasing the operating margin requires removing more pressure drop from the system or adding more head.

Reducing pipe pressure drop gives little benefit. The piping system has no specific hydraulic choke points. Achieving pressure drop savings from pipe changes would necessitate extensive pipe modifications for modest benefit.

The two new orifice plates incur a 5.1-psi pressure drop. Using a lower-pressure-drop measuring instrument could reduce this. Ultrasonic flow meters might be a good choice.

Replacing exchangers E1 and E2 could save some pressure drop. However, this would be an expensive change for a modest gain.

Increasing the head available requires pump modification or replacement. Pump P1 has a less-than-maximum-diameter impeller. Switching to a larger diameter impeller would add more than 10% head capability. Unfortunately, the motor on P1 is too small for a larger diameter impeller. Installing a larger impeller also demands a larger motor.

Regardless of the solution, the plant must accept some combination of:

- potentially lower-than-desired flow rates;
- further capital investment to lower pressure drop; or
- additional spending to increase head available.

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