

CHEMICAL ENGINEERING

December
2005



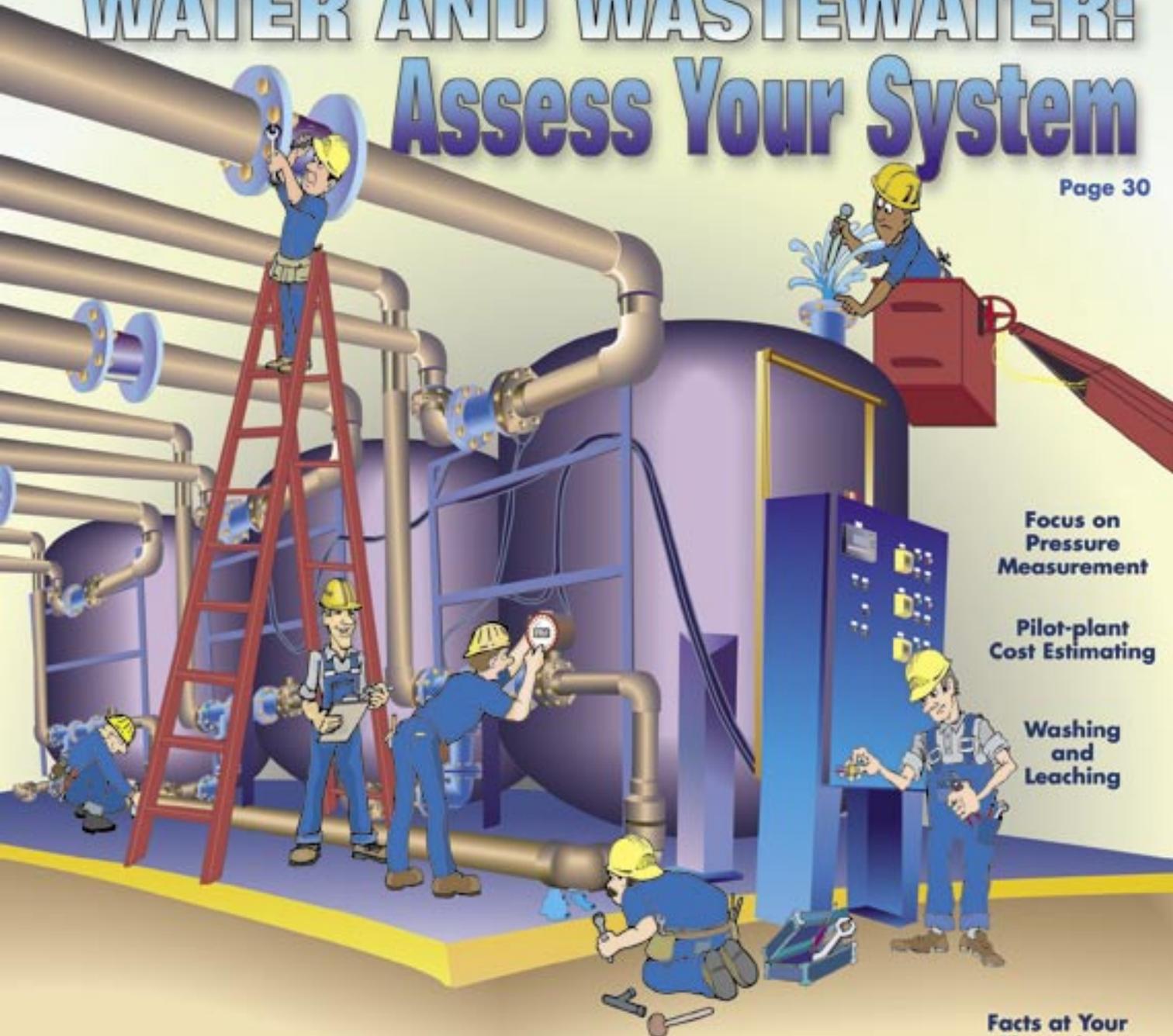
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WATER ASSESSMENTS: In Search of Hidden Dividends

**A close look
at all aspects of your
water- and wastewater-treatment systems
can reveal opportunities for cost savings,
improved operation, reduced downtime
and better water conservation**



Jeff Miladin
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A variety of factors dictate the water-treatment needs of any chemical process plant. For instance, many industries depend on high-quality inlet water to produce their end products. Meanwhile, wastewater generated by chemical process operations must be treated to meet local, state and federal environmental guidelines. Many industrial plants are also working to reduce the total volume of water they use, to conserve this valuable and increasingly costly resource.

For these reasons, it is vitally important that a facility's water- and wastewater-treatment systems operate in the most efficient and cost-effective manner. By carrying out a comprehensive, onsite water assessment, engineers can gain critical insight into their operations and uncover ways to ensure cost-effective operation and guarantee consistent compliance with water-quality standards while con-

serving water. And in many cases, such an assessment can help engineers to improve operations and maintenance practices in a way that reduces costs and downtime.

Water assessments: The what and why

A water assessment consists of a review of all equipment that is used to treat process water and wastewater at the plant. Process operators should conduct a water assessment whenever they suspect a possible problem, either because they are not getting the desired quality and quantity of water, or because the individual unit processes are performing below expectations or specifications (this aspect is discussed in detail later).

However, you don't have to wait until there is a problem. Perhaps your water-treatment equipment is old and you're wondering if it would make sense to upgrade or replace individual components or the whole system. Perhaps you would like to know if your plant is using water in

the most efficient manner to reduce operating costs and encourage recycling and reuse. By conducting a water assessment at your facility, you can identify equipment that needs to be tuned up or replaced, and determine whether additional equipment should be added to enhance the treatment capabilities of the existing system, in terms of economics, throughput volume or pollutant-removal capabilities.

The system-wide evaluation will also give you the opportunity to evaluate whether any additional equipment that may be needed as a result of the assessment should be handled as a purchased, permanently installed system, a build-own-operate system, or a temporary mobile system. Such a decision will depend on the site-specific operational needs and budget. In general, it also makes sense to schedule an assessment before every scheduled plant outage, so that any work that needs to be done can be completed in an orderly fashion during the planned facility downtime.



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FIGURE 1. Proper instrumentation and calibration are essential to verifying system performance and alerting plant personnel to problems before they get out of control

Some unit operations or processes are, by nature, prone to developing water-related problems. For example, reverse osmosis (RO) systems may develop problems if their membranes are not cleaned properly, or at appropriate intervals, to maintain their design performance and throughput. Improper cleaning, or cleaning that is done too late, may cause irreversible damage to the RO membranes and result in compromised system flow or diminished product water quality.

A timely water assessment can also ensure that you are prepared for a short-term or emergency water system “outage” by developing a comprehensive plan to manage these situations. The plan would take into account identified weaknesses in the existing system and provide for a way to address the failure of those components. This plan could include adding provisions for emergency mobile equipment, improving system redundancy, or simply making sure the plant has the proper spare parts inventory for high-wear parts. It should also include detailed

instructions on what the plant should do operationally to minimize the impact of a water-related failure.

Diagnosing water-related problems

The following symptoms are often encountered in chemical process plants, and may indicate a water-related problem:

- Reduced product flow or quality
- Reduced run lengths on ion exchange applications
- Increased pressure differentials across units
- Increased consumption of acid/caustic/brine for regeneration systems that experience long periods of service
- Online system instrument readings that disagree with those of lab instruments that are used to verify the accuracy of, or to help diagnose problems with, the water-treatment system instruments

In addition, the following events can create water-related problems:

- Changes in makeup water source

- Seasonal variations in makeup water sources (such as minerals, turbidity, and temperature)
- Running systems beyond their design limits (for instance, in emergency situations)

What’s involved?

A water assessment can be as comprehensive as reviewing all aspects of all process operations, including those related to process control, instrumentation, vessels, piping, influent and discharge water quality, or it may be as simple as reviewing one specific part of the process. As a general rule of thumb, a full-fledged, comprehensive water assessment is called for if any of the following criteria are met: your system has been in service for over five years, has been poorly maintained, is operating less efficiently or is not meeting final water quality specifications.

An assessment that is designed to optimize your process typically involves the following protocol: A work team is established to evaluate the facility’s water-related operation and maintenance activities, and review any seasonal variations in plant influent water quality, or changes in demand for process or wastewater flows. The team reviews maintenance logs to make sure proper maintenance has been carried out at appropriate intervals, and that all systems are being operated at the correct flows and pressure according to design data and associated process and instrumentation drawings (P&IDs). A thorough inspection is carried out for each unit operation, if required. For example, the team might perform the following activities during an assessment of an ion exchange vessel:

- Inspect, repair, rebuild vessels (verifying lining integrity), internals (including distribution plumbing and strainers), and valves, and verify the proper operation and control of each
- Inspect, test, add and replace the ion exchange resin as needed
- Regenerate saturated resin to ensure the performance of the system
- Audit the brine, acid and caustic consumption of the resin-regeneration system

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Don't wait for system failure to pay attention to your water-related systems. Regular, early assessment can ensure that inlet and outlet water flows at the expected rate and meets quality specifications



FIGURE 2. Since the performance of pretreatment systems can dictate the overall success of any water-treatment system, regular verification and validation of filtration media and valve performance is important

- Upgrade all controls
- Fix any system leaks

Once the inspection is complete, the overall system operation should be verified against the system P&IDs. If modifications are required to meet design flows or water quality, they can be implemented at this time.

How long will an assessment take?

The time it takes to do an assessment will vary, depending on who conducts it and whether it is carried out as a full-fledged, complex assessment of all water-related aspects of the entire facility, or one that reviews just a single part of the process. Assessment will proceed more quickly when design drawings and other documentation are readily available from plant personnel. It may take longer when critical documentation has to be reconstructed.

Third-party service providers typically take 30 to 60 days to do an assessment from start to finish. This includes developing the scope of the assessment, performing the equipment review, and creating an assessment report. The assessment report verifies the scope of the project and details the current and desired condition of the system, and then outlines the remedial steps needed to reach the desired outcomes.

What about cost?

The cost of a water assessment reflects the time spent by internal plant personnel or external third-party service providers to conduct the assessment. A likely outcome of the effort is that the need for upgrades or repairs will be identified, so the costs associated with repairing or replacing the equipment once any problems have been identified must also be factored in.

Although you may be reluctant to spend money to upgrade an older system still producing water of sufficient quality, this decision could be shortsighted, as water-related failures may have a dramatic impact on plant operations. When deciding whether or not to repair or upgrade the system, you must weigh the cost of the repair against the long-term potential gains in efficiency, or improvements in system performance, as well as the costs associated with unscheduled interruptions in process water availability or insufficient water- and wastewater-treatment capabilities. Table 1 provides several examples that can help you to decide whether a water assessment is recommended for your specific situation.

Should you do an assessment?

How do you know whether or not you should do an assessment? Let's use a

real situation to help answer this question.

One mining operation operates a large water-softening system that feeds the entire plant complex. Over the last year, the facility experienced shorter run lengths than expected from the ion exchange resin beds. Since the raw water hardness had remained unchanged, the plant elected to increase the feed rate of the regenerant brine, fearing that the brine-injection pumps were not pumping as well as they had before. However, even after having raised the brine flowrate, the plant did not experience any meaningful increases in the run lengths of the water softeners. Having thus tried all the easy things, plant managers decided to engage a third-party service provider to perform a water assessment to determine how best to solve the problem.

An inspection inside the softener vessel revealed low resin levels and channeling inside the resin bed, which had resulted from a distribution system failure. The channeling had contributed to the short run lengths. The inspection also revealed that the vessel lining had failed in a few areas. The assessment team developed a plan with the mine operation personnel that met the production needs.

During the overhaul of the water-

TABLE 1. EXAMPLES OF WATER ASSESSMENT RECOMMENDATIONS FOR SPECIFIC SITUATIONS

Situation	Seriousness	Action
The water plant, and each unit process (clarification, filtration, RO and demineralization) are producing the quality and quantity of water needed and expected. The required inputs of chemicals, energy, labor and maintenance are in line with design specifications. Wastage via backwash, reject and regeneration is also in line with design specifications.	Green light	Consider future water requirements, possible raw-water alternatives, emerging environmental restrictions and contingency plans to maintain current high level of performance.
The overall water plant is producing the desired quality and quantity of water, but individual unit processes are performing below expectations or specifications.	Yellow light	Conduct water assessment to focus on specific unit process, before downstream units or overall water plant performance is compromised.
The overall water plant is producing the desired quality and quantity of water, but required inputs in terms of chemicals, energy, labor or maintenance are above expectations, specifications or industry norms.	Yellow light	Address water plant or unit process inefficiency that is resulting in higher operational costs. Conduct water assessment to optimize performance and reduce costs.
The overall water plant is producing the desired water quality and quantity, but wastage via backwash reject or regenerations is above expectations, specifications or industry norms.	Yellow light	Address water plant or unit process inefficiency that is resulting in higher operational costs. Conduct water assessment to optimize performance and reduce costs.
The overall water plant is not producing the quality or quantity of water needed and expected. Manufacturing operations may be compromised or curtailed if the situation is not remedied quickly.	Red light	Conduct water assessment immediately and consider using mobile water treatment to safeguard manufacturing operations.

softening system, resin was restored to its proper level, the distribution system was repaired, and a new liner was installed. To verify that the unit was being operated correctly and to find out if the regeneration sequence was correct, the assessment team performed an elution study, for confirming the effectiveness of the regeneration process. The team discovered that while the sequence and brine dosage were correct, the pressures in the system had varied considerably. This had probably caused the resin to become backwashed out of the system during a high-pressure spike, and it may have contributed to the distribution system failure, as well. The assessment team installed a pressure-regulating valve, and the flow problems were thereby eliminated.

Lessons learned

Discussed below are some examples of how a water assessment helped four industrial plants to optimize their operations.

Helping with an expansion project. A power plant expansion in the U.S. Southeast required 10 million gallons of water total to start up two new units. The raw feed was surface water from a 40-acre power plant reservoir, which required pretreatment with chlorine, polymer feeds and media

filtration to remove unwanted organics and suspended solids. A water assessment determined that the best response to this short-term, high-flow requirement was to install a mobile demineralization system provided as part of a temporary system for hydraulic test and steamblow (a process that is used during the commissioning phase of any power plant, to clean the plant steam piping before it is put into service). The system would supply 1,000 gal./min of boiler feedwater for this steamblow project.

The third-party water-assessment team supplied the plant with mobile demineralizer trailers, complete with pretreatment, and has now been operating the system for six years as part of a permanently installed “build-own-operate” system. The system continues to meet the customer’s water specifications and budget for the steam plant project.

Addressing an issue with aging equipment. A water assessment helped a petroleum refinery in the U.S. Gulf Coast to solve a problem with its filtration system. The refinery had installed nine automatic valveless gravity filters for filtering clarified river water.

After almost 40 years in service, however, the units were showing signs of aging. A complete system evaluation

showed that the replacement strainers installed in the units did not meet O.E.M. specifications and were improperly designed, allowing filtration media to be lost. Further inspection also determined that the replacement media was not properly sized. Besides having improper strainers and media, the equipment suffered from corrosion and lack of maintenance. The water-assessment team determined that installing original manufacturer-designed stainless steel strainers would eliminate the problem.

However, an inspection of the individual vessels revealed that a few of them furthermore had structural and operational problems that could not be corrected with typical repair methods. The water-assessment team recommended structural repair and/or replacement specific to each unit, and suggested operational changes that made an immediate impact on unit operation.

Since the initial inspection, refinery personnel have replaced the media and strainers in three of the nine vessels, and have ordered new AVGF units to replace two whose condition was too poor to be repaired. This immediately improved the water quality from the filters that were repaired, and brought a corresponding improvement in the operation of downstream

equipment. As soon as all nine units are repaired or replaced, the plant expects to reap savings in terms of water-treatment chemicals, improved operation of plant cooling exchangers, and reduced cost associated with demineralizer operation.

Helping a plant stay online with mobile treatment. When a U.S. Midwest steel plant was investigating its water-treatment options, a water assessment suggested that outsourcing was the best solution. By contracting their water-treatment operations to a third-party service provider, plant personnel would be able to focus their resources upon their core business. When market conditions turned downward, however, the plant personnel ended up putting their outsourcing plans on hold.

In the meantime, the plant's pretreatment system failed, and the facility required a mobile pretreatment system to get its production back online quickly. If it had shut down its steel production, the plant would have lost more than a million dollars per day. A combination of five mobile trailers produced the water quality needed for its process.

Had the relationship with the external water-treatment vendor not been formed during the earlier water assessment, and had the vendor not understood the customer's requirements, the plant would have been forced to constantly blow down its boilers, resulting in higher water, fuel and chemical costs.

Helping a refinery plan for an outage. A Gulf Coast refinery had scheduled a one- to two-week outage for its cold-lime softening system, which clarified the incoming water while reducing hardness. It initially sought to install a filtration system to replace the clarifier during the outage; however, an assessment of its current water condition and systems determined that the desired water quality and predictable flowrates could not be guaranteed, due to high turbidity of the incoming water.

In addition, the use of filtration alone (in lieu of the existing water-

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FIGURE 3. Reverse osmosis membranes can be cleaned onsite or off-site, depending on your facility's needs. Auditing membrane condition on a regular basis can alert you to other issues within your water-treatment system

softening system) would not address the abundance of hardness minerals in the inlet water. After further review of the specifications, the refinery determined that the best solution was to install mobile clarification equipment on a temporary basis, to provide treated inlet water that met specifications while the existing system was taken off-line for scheduled maintenance. Mobile clarifiers, combined with a side-stream zeolite softener, were able to produce the same quality of water as a temporary system.

Three clarifier trailers were delivered to the site, providing a total flowrate of 3,500 gpm, with a maximum turbidity of 5 NTU. Delays during maintenance work on the refinery's existing clarifier required that the mobile units remained onsite for an additional five weeks.

The mobile clarifiers met the specified water flow and quality, and allowed the refinery to complete maintenance on its existing system without interrupting production. The ability to use a trailer-mounted mobile clarifier prevented an unscheduled outage at

the refinery, and allowed the required maintenance work to be done in an orderly manner.

Getting organized

When a chemical process operator decides to hire an outside water-assessment team, plant personnel should assemble the following types of plant documentation and data to help facilitate the assessment:

Documentation:

- System operating manuals
- P&IDs for the water-treatment system
- Schedule of preventive maintenance done on the system

Data related to:

- Wastewater produced by water-treatment system (compare actual performance with system design and analyze any excursions)
- System acid/caustic consumption
- Replacement history for cartridge filters, resin, membranes, and media
- Makeup water and product water-quality measurements
- Operating schedule (hours/days/week/year)

Inlet water and wastewater are essential parts of most chemical process operations, and the ability to treat water so that it meets process specifications and regulatory thresholds is of critical importance to the smooth operation of the facility. By conducting timely water assessments, operators can identify opportunities for improvement, and take steps to rectify sub-par performance in the most orderly and cost-effective manner, thereby minimizing the risk of system failures or unscheduled downtime. ■

Edited by Suzanne Shelley

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