The Hidden Cost of Equipment Failure in Wastewater Plants

How prognostics can help WWTPs optimize costs and improve reliability.

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IMAGE 1: Prognosis chart for a well-functioning asset (Images courtesy of Novity)

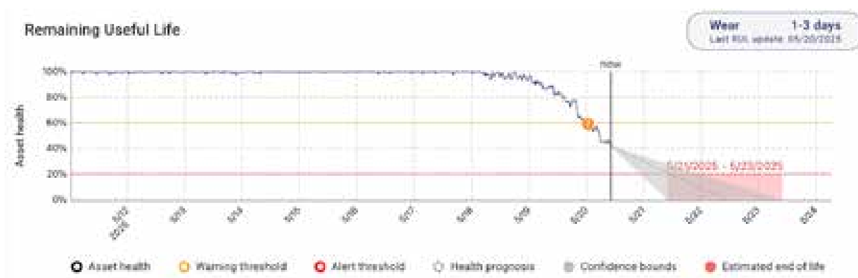

IMAGE 2: Condition monitoring dashboard showing increasing vibration in a critical effluent pump

Wastewater treatment plants (WWTPs) operate under immense pressure to maintain uptime, manage aging infrastructure, comply with strict environmental regulations and deliver reliable service to their communities. Yet despite this critical role, many facilities still rely on outdated maintenance strategies—waiting until machines fail or servicing them at fixed intervals with no insight into actual health.

This approach is not just inefficient, it is costly. Unplanned equipment failures often trigger ripple effects that extend far beyond the maintenance budget: environmental violations, compliance penalties, public trust issues and operational disruptions.

By leveraging sensor data and predictive analytics, WWTPs can anticipate problems before they occur and plan interventions based on remaining useful life (RUL) estimates. Modern condition monitoring systems that enable fault prognosis can take advantage of both process data and Internet of Things (IoT) sensors, maximizing the benefit while keeping costs minimal. This article explores how prognostics help utilities avoid the hidden costs of failure.

The Real Cost of Equipment Failure

Most utilities are aware of the direct costs of equipment failure: the labor to fix the issue, the price of replacement parts and any immediate downtime.

What is often overlooked are the indirect costs, which can be much more damaging:

- Regulatory penalties for permit exceedances or unauthorized discharges
- Environmental and cleanup expenses from sanitary sewer overflows or spills
- Loss of public trust and negative media attention
- Disruption of downstream processes, causing cascading slowdowns
- Increased operator stress and overtime, as well as reduced morale

Equipment failure is considered one of the top three causes of sanitary sewer overflows, responsible for as many as 25% of these incidents,[1] frequently resulting in noncompliance events and fines. For example, the city of Memphis experienced a major spill of millions of gallons of untreated sewage into the Mississippi River after a pump failure in 2016, generating public scrutiny, environmental costs and settlement costs of $600,000.[2]

These incidents illustrate a critical point: The cost of failure is rarely limited to the failed machine itself.

High-Risk Assets in Wastewater Plants

While WWTPs contain hundreds or thousands of mechanical assets, a subset of them carry disproportionate operational and compliance risk:

- Aeration blowers, which consume up to 60% of plant energy and are essential for biological treatment[3]
- Effluent pumps, responsible for discharging treated water and maintaining flow regulation
- Centrifuges and dewatering systems, which, when offline, can cause sludge backups and storage overruns
- Return activated sludge (RAS) and influent pumps, critical to flow continuity and process balance
- Filters and separators, responsible for separating particulates of various sizes (e.g., cyclone separators/sedimentation, etc.) all the way down to chemical contaminants and dissolved components (e.g., reverse osmosis, membrane filters, etc.)

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These systems are often operating 24/7 in corrosive or abrasive environments. Failure modes—like bearing wear, cavitation, seal leaks or impeller damage—may start subtly but escalate quickly without proper monitoring.

Despite this, many utilities still rely on manual checks or motor current readings to assess condition, which are insufficient for early fault detection.

How Prognostics Prevent Failure

Prognostics take maintenance one step beyond monitoring by predicting when an asset is likely to fail, giving teams time to respond. This is made possible by tracking trends in sensor data (vibration, temperature, pressure, current, etc.) and using models to estimate an asset's RUL. Image 1 is an example of a RUL chart for an asset where no fault is under development, providing the operator reassurance that the machine is operating as it should.

A prognostic system typically includes:

- Sensor instrumentation on critical machines to detect degradation
- Trend analysis and anomaly detection, using either rules-based logic, sophisticated physics models of machines or processes or AI/machine learning (ML) models
- RUL estimation, giving advance notice of potential failure
- Integration with a computerized maintenance management system (CMMS) or supervisory control and data acquisition (SCADA) systems for automatic alerting and work order generation

This level of foresight allows teams to schedule maintenance during normal working hours, avoid unplanned downtime and ensure parts and labor are available in advance.

The benefits of doing this well can be staggering. It has been reported that truly predictive maintenance in utility and industrial settings can reduce downtime by 20%-50% and reduce maintenance costs by 20%-30%.[4]

Real-World Scenarios: Planned vs. Reactive Response

To illustrate the value of prognostics, consider two simplified scenarios drawn from industry case studies:

Scenario 1: Effluent Pump Failure

- ***Without prognostics:*** A pump seizes during peak flow. Operators scramble to shut down the process and call in night-shift contractors. An overflow occurs, resulting in a $15,000 fine and local news coverage.
- ***With prognostics:*** Two weeks earlier, trending vibration levels cross a degradation threshold. A work order is generated, and the bearing is replaced during a scheduled maintenance window. Total cost: $2,500. There is no spill, no fine, no incident.

Scenario 2: Aeration Blower Degradation

- ***Without prognostics:*** A blower bearing fails, resulting in six hours of under-aeration. Biological performance dips, risking effluent quality. Recovery takes days and increases energy consumption.
- ***With prognostics:*** A trend in vibration readings triggers an RUL forecast, and vibration spectrum analysis confirms a looseness diagnosis, indicating failure risk within 30 days. Maintenance is performed in advance. No disruption occurs.

In both cases, the technology did not eliminate failure modes—it moved intervention from reactive to proactive and reduced the cost and disruption exponentially.

Getting Started With Prognostics

Implementing a full predictive maintenance program may seem daunting, but the path forward can be incremental and affordable:

1. ***Identify high-impact assets:*** Start with machines that have failed before, are compliance-critical or are difficult to replace on short notice.
2. ***Review common failure modes:*** Review how the machines have failed in the past. If this data is not available, there is typically literature that describes the most common failure modes for each machine type.
3. ***Install targeted sensors:*** Use the appropriate sensors for the machine and failure modes in question. Wireless vibration, temperature or current sensors are available at low costs and are easy to install.
4. ***Analyze and alert:*** Feed data into a monitoring platform capable of generating alerts and RUL estimates. Many modern tools are available as cloud-based subscriptions, minimizing IT overhead.
5. ***Quantify and share results:*** Track avoided failures, reduced emergency costs and improved uptime. Use this data to build internal support and justify broader rollouts.

Predict the Problem, Prevent the Cost

For WWTPs, the cost of equipment failure is rarely just about a broken part—it is about the cascading consequences of noncompliance, environmental harm, reputational damage and human stress. Fault prognostics and condition monitoring give plant operators the power of foresight. ■

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