Maintenance Strategies: Predictive Maintenance vs “Run to Fail”

Water and Wastewater Systems

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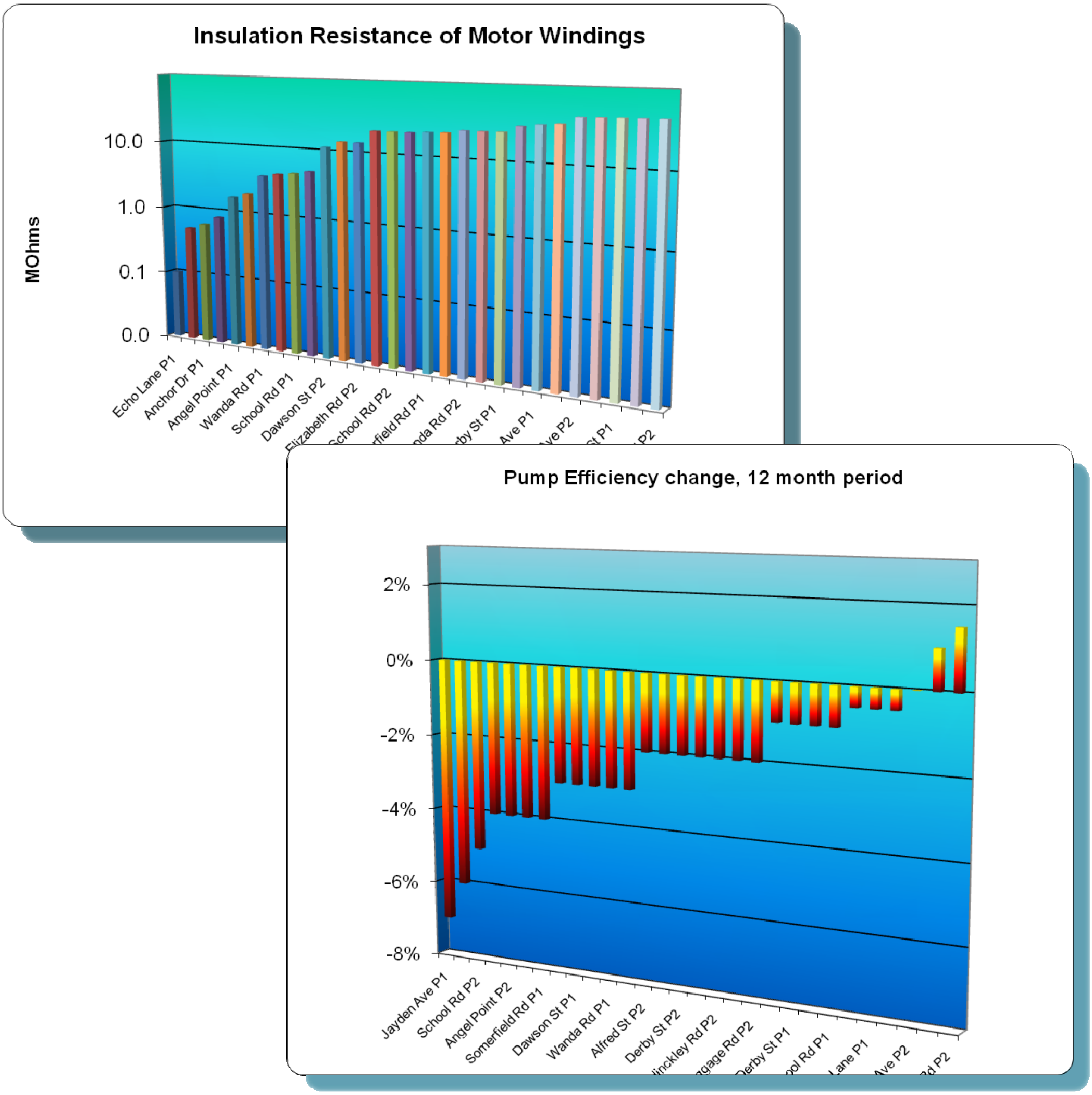

One of the most common questions from water and wastewater utilities when they are asked about their maintenance practices in lift stations is: *"What do other organizations do?"*

Across the US, UK and Australia the maintenance methodologies vary from one end of the spectrum to the other.

Maintenance practices for utilities include **run to fail, preventive maintenance** on a schedule of time or time in service, and **predictive maintenance** by monitoring leading indicators of pump and motor problems.

Most people will be familiar with these terms, but it's worth briefly reviewing them.

Run to fail implies that the organization will expect inevitable failures and will have sufficient spare parts and staff on hand to keep the downtime below organizational requirements. The allowable downtime is usually calculated on a station-by-station basis.

Preventive maintenance and **predictive maintenance** have been neatly contrasted in a recent article by Thompson and Granger:

> **"**By applying advanced diagnostic technologies to the issue of equipment maintenance, the probability of any one piece of equipment continuing to operate effectively can be accurately determined. Repair crews can check on advance warnings, not the calendar, before going out to inspect, tear down (if necessary), and repair a piece of machinery. This is the essence of predictive maintenance, and it's far less expensive than the old fashioned preventive maintenance so many of us grew up believing in.
>
> For years companies have been performing the preventive maintenance recommended by manufacturers with out question. The reasoning being that manufacturers have done all the research needed to ensure their equipment will operate properly in any environment. Most companies also want to ensure that equipment warranties are maintained during the initial installation period. Once these maintenance actions are entered into the CMMS or work routine, no one challenges their validity or periodicity because "that is the way we have always done it". This can be a very costly way of doing business." [1]

Run to fail

From our surveys, across the majority of utilities in the US and Australia the most common methodology was run to fail. Manpower shortages and/or lack of a budget for better monitoring and control were by far the most common explanation for this choice.

One very large utility had a stated policy of run to fail, but this was a deliberate policy based on its own assessment of the costs and benefits of alternatives. This policy had the benefit of simplicity. It had to maintain enough store locations to keep an adequate amount of spare parts, and it had to have enough trucks and maintenance crews so it could replace any pump within a set number of hours.

This example was definitely an exception. Many smaller organizations were divided on their "de facto" policy of run to fail. Some felt that although there should be a better solution, the current scheme was working "because we don't get that many failures." Those organizations that believed their policy was not optimal were experiencing continual failures and breakdowns, with staff doing only reactive "firefighting."

[1] *What Price Preventive Maintenance?* T. Thompson and M. Granger, 2004

Preventive maintenance

More common among medium-sized and larger organizations was a level of preventive maintenance, e.g. servicing the impellers and seals within a set timeframe or amount of run time (e.g. every 6 months, every 5000 hours, etc).

While easy to fault--why not one time period than another?--organizations with preventive maintenance procedures believed that run to fail was flawed and there was a “duty of care” responsibility to keep the assets in a good condition. Most utilities with this methodology acknowledged that they didn’t know whether they were doing too much maintenance. However, in most cases they were comfortable with their level of spending and weren’t experiencing a high level of failures. It should be noted that their comfort with their level of spending was usually because they had become accustomed to it.

It was common to find this group of users beginning to use predictive maintenance to some level, with the most common strategy being meggering motors manually.

Predictive maintenance

What predictive maintenance is possible and practical on submersible centrifugal pumps, the pump choice for lift stations?

Insulation Resistance Testing – Also known as **Meggering** the motor, this tests the integrity of the motor windings, which break down over time. Between half to three-quarters of motor failures in submersible pumps are caused by the insulation breaking down.

With this method, users must choose between a manual test on a periodic basis or an automatic test.

Pump Flow Rates – This tests the hydraulic performance of the pump. Since most wastewater lift stations don’t have flow meters, this is usually not monitored; instead, the proxy of hours run is commonly used. However, hours run can increase because of higher throughput or deterioration of pumps.

Pump Efficiency – This measures volume pumped per energy unit (KWHr or KVAH). This is a more effective measure as it also provides the financial impact of deteriorating pumps, letting the organization know the cost of the problems

A few other methods are worth mentioning:

Seal faults – These are very common, as most pump vendors provide them as standard or as an option, but they give an early warning of water leakage so they are providing predictive maintenance.

Three-phase currents – Most US lift stations don’t have current meters, but they are standard in the UK and Australia. Typically, they have a line drawn on them for the expected current draw. As a local indication, it is a very limited tool – but providing the three-phase current remotely would provide another predictive maintenance indicator.

Three-phase supply – This information is rarely available remotely, but if it is, will supply information for predictive maintenance, for reasons touched on later.

In the UK, due to the large size of each of the water/wastewater utilities, almost all have a plan to introduce predictive maintenance – also known as condition-based monitoring. However, due to the cost and complexity currently involved in implementation, the UK is still mostly a mix of run to fail and preventive maintenance.

The main perspective in the UK is that the organizations are “asset managers,” and as asset managers they cannot afford to “fly blind” but require real data to know the status of all of their assets. There is also a major focus on energy costs and the associated “carbon footprint,” with this factor becoming as important as pump and motor lifetime.

One very large US utility has a team of electricians who visit every site every three months to carry out an insulation resistance test on their motors--a very expensive exercise. Across the US, this practice is found in less than 10% of utilities.

Challenges

The major problem with run to fail is that it is a choice to fly blind as to the state of the assets. While there are many reasons why pumps and motors can deteriorate faster than historical data shows, there isn’t space in this article to detail all of them. However, an excellent example is given in an article in *Pumps & Systems* (http://www.pump-zone.com/motors/motors/unbalanced-voltages-and-electric-motors.html) by Thomas H. Bishop.

Bishop's article outlines the effects of slight voltage imbalances on pump lifetime. There are similar effects on lifetime for small undervoltages.

A practical example of this occurred at a large regional municipal utility that introduced a predictive maintenance product into the lift stations; at that time they discovered why so many pumps were failing before 7-8 years in one area instead of the expected 25 years. The 3-phase supply was around 10% below nominal, and because the 3-phase supply wasn’t remotely monitored, no one was aware of it. The supply reduction was causing higher running currents, but not enough to trip any panel components or the pump thermistor. Still, the pumps were running too hot, causing a big reduction in lifetime.

The major problem with Preventive Maintenance is that it is expensive--and hard to justify:

> “The challenge is to find the correct time interval: some machines will be dismantled unnecessarily, yet others will fail because they were not inspected often enough, others will fail after maintenance work because some human-induced error has been made.” [2]

However, in the absence of a cost-effective predictive maintenance tool, many organizations are using preventive maintenance in an attempt to be better asset managers.

The major problem with Predictive Maintenance <u>used to be</u> cost.

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[2] *Predictive maintenance of pumps using condition monitoring* Beebe, Raymond S., 2004

Meggering motors used to be done by sending electricians to each site, which is very costly.

Measuring flow by installing flow meters at each wastewater lift station is also very expensive. A number of products and algorithms are available to do calculated flow via draw-down tests, but typically they only measure outflow at the station and don't break that down into individual pumps. Algorithms over SCADA face a number of problems, not the least of which in the US is that the communications protocols (Modbus is the most common) mostly do not give a date/time stamp, so there is some uncertainty as to when the pumps started and stopped.

Lastly, there weren't products around that measured pump efficiency (gals or liters per kWHr).

(It should be noted that using predictive maintenance (and preventive maintenance) still requires spare parts and response crews, although the investment should be significantly less than in the case of run to fail).

New Technology

As is often the case, new technology can significantly change the industry. In 2006, the first pump station manager (MultiSmart from MultiTrode) was released.

This product has made cost-effective predictive maintenance viable for the first time.

A pump station manager combines a sophisticated pump controller, PLC, RTU and user interface into one unit which also measures 3-phase supply, 3-phase currents, power, energy, flow rates per pump, pump efficiency and insulation resistance testing (meggering). All of the data is available remotely, as the pump station manager can be connected to any open SCADA system.

Pump station managers like MultiSmart have allowed predictive maintenance to emerge as the best practice for lift stations.