LOAD CONTROLS INCORPORATED

PUMP MOTOR POWER ...TIMES FOUR

How to Leverage Motor Power Across Varying Timelines to Protect and Optimize Pump Environments

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Special purpose pump motor power sensors and controls have been available for over 25 years. Because power levels from pump motors relate directly to pumping work being performed, these sensors and controls have proven useful to protecting pumps and motors. Changes in motor power can provide early feedback that could indicate abnormal events such as dry running, cavitation, overloads or bearing failures. This early detection of faults is particularly useful in applications where the fluid being pumped is valuable, dangerous, or particularly messy if it gets out into the environment. Similarly, this protection is highly important in any environments where downtime is costly.

Recent advances in networking, storage and processing power have expanded the use of this power data from pump and motor protection to include predictive maintenance, energy monitoring and early fault prediction. By looking at pump motor power over four time horizons the same data can provide all these insightful benefits.

1) Pump Motor Power every ½ Second: Pump and Motor Protection

For industries pumping fluids that are valuable, messy or dangerous when exposed to the outside environment pump motor controls have provided vital insurance to protect motors and pumps and ensure fluid remains safely inside the pumping environment.

By sampling power levels twice a second, pump managers can react quickly to changing conditions such as cavitation, jams or dry running. This half-second interval nicely balances real-time data needs with the elimination of false alerts a more frequent sampling might create.

Measuring power requires no direct mechanical attachment to the pump or motor and can be done in an environment (power distribution panel) free from potential manufacturing hazards such as the Motor Control Cabinet.

Benefits of Power monitoring include real-time feedback on process status, flow and viscosity changes, dry running, cavitation, impeller loss and other error conditions and maintenance issues

Magnetically coupled, “seal-less” or “canned” pumps are increasingly being specified for critical and environmentally sensitive pumping applications. These pumps offer several clear advantages, but since the bearings are now inside these pumps, a steady flow of fluid is needed to remove heat buildup. For some specific use case studies on protecting these pumps please refer to the scholarly article *Mag Drive Pumps: Why They Work - How They Fail* [1] and the article in the September 2020 issue of Pumps and Systems titled *How Long Can I Run My Pump Dry?*.[2] Both articles point out the challenges of these advanced pumps and recommend the use of power sensors to monitor and protect them.

Power measurement can be used alone or as part of a multi-mode measurement program. Other techniques for monitoring pump status include:

Flow Meters

Measuring flow can provide throughput and viscosity data, critical to understanding subsystem status. A potential downside—the most effective measurements are taken in the flow, leading to reliability and maintenance concerns. Flow Meters can also be costly to install. Leveraging flow sensors in addition to power measurement can be valuable when viscosity changes are important to pump efficiency. Both can provide rapid feedback on flow loss and impeller damage. Addition of power monitoring affords a second source of data, generated away from the process’ environmental hazards.

Vibration Sensing

Measuring vibration provides feedback on pump balance and bearing wear. Since vibration will increase with ongoing wear and misalignment, vibration sensing is commonly used in preventative maintenance programs. Ultrasonic vibration measurement can provide some insight into process state. Vibration sensing is typically easy to install, although may be more expensive than power measurement alternatives. They will also require physical access to the pump which may be problematic. The combination of vibration and power sensing over time can provide valuable insight into ongoing pumping costs and maintenance efficiencies.

Temperature Monitoring

When implementing temperature sensing in pumping applications a decision needs to be made to measure temperature in flow, or pump/motor housing. Measuring temperature in flow is most accurate but will require ongoing maintenance. Housing-based solutions are simplest to install, but may suffer from accuracy and latency challenges, particularly in canned pumps as described in the referenced articles. You may also require an ambient temperature sensor to ensure measurements reflect the process, not external factors. Leveraging temperature alone is unlikely to diagnose overheating or impeller failure in a timely fashion. When used with Power sensing, temperature monitoring can provide accurate centipoise readings enabling viscosity-based process decision making as well as faster detection of cavitation.

The ability to safeguard pumping equipment, minimize or avoid downtime, and ensure smooth ongoing pumping is the staple of the pump motor power sensor.

2) Pump Motor Power every 5 Minutes: Efficiency and Predictive Maintenance
Newer pump motor power controls can capture and retain regular snapshots of power levels over a month's interval. Comparing pump motor power of this frequency with pump system pressure and flow data provides a complete picture of pump efficiency and operating location on the pump curve.

Monitoring the 5-minute capture curve over a month can track system degradation and enable improved prediction of impending faults. Bearing wear, shaft misalignment, clogging and impingement, and other potential maintenance requirements affect the pump HP level proportionally. The more power the pump will pull to accomplish the same amount of work, the higher the measured HP. The entire curve will be offset by the change in power measured due to the maintenance concern, as shown in Figure 1 in blue.

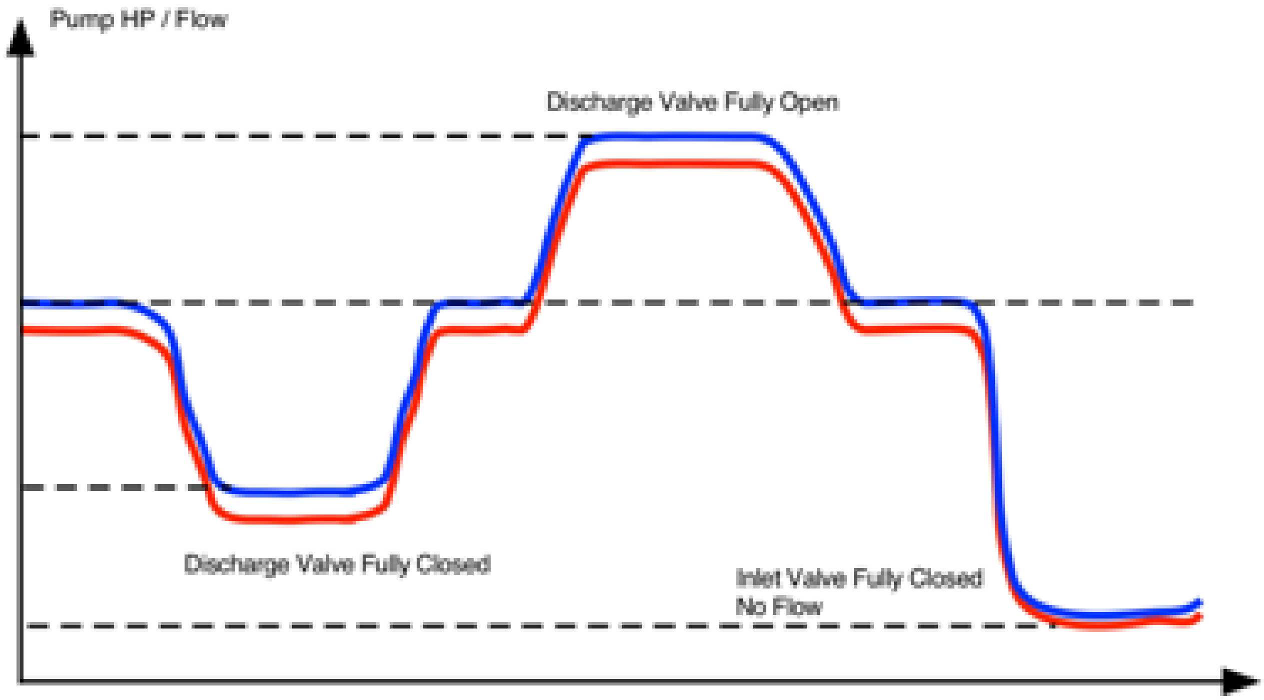


Figure 1: Changes in power from steady state with potential maintenance issue
Courtesy: Load Controls, Inc.

Monitoring the vertical shift samples every 5 minutes over time can show the increase in HP, providing insight into process efficiency and the potential need for proactive maintenance.

3) Pump Motor Power monthly averages for 3 years: Sizing and Energy Efficiency

It’s no secret that industrial pumps, and the motors that power them, are among the largest users of global energy production. Industry surveys have highlighted that as many as 70% of all pump motors are at least 20% oversized. When used to retain several years of power history, pump motor power sensors and controls allow organizations to pinpoint the largest users of purchased energy and address the best candidates for optimization and reduction.

Figure 2 is an example pump curve. For the required Flow of 500 gpm and Head of 75 ft we can see that a Best Efficiency Point (BEP) with corresponding recommended motor HP can be located on the curve. In this example the BEP would dictate a 25HP motor.

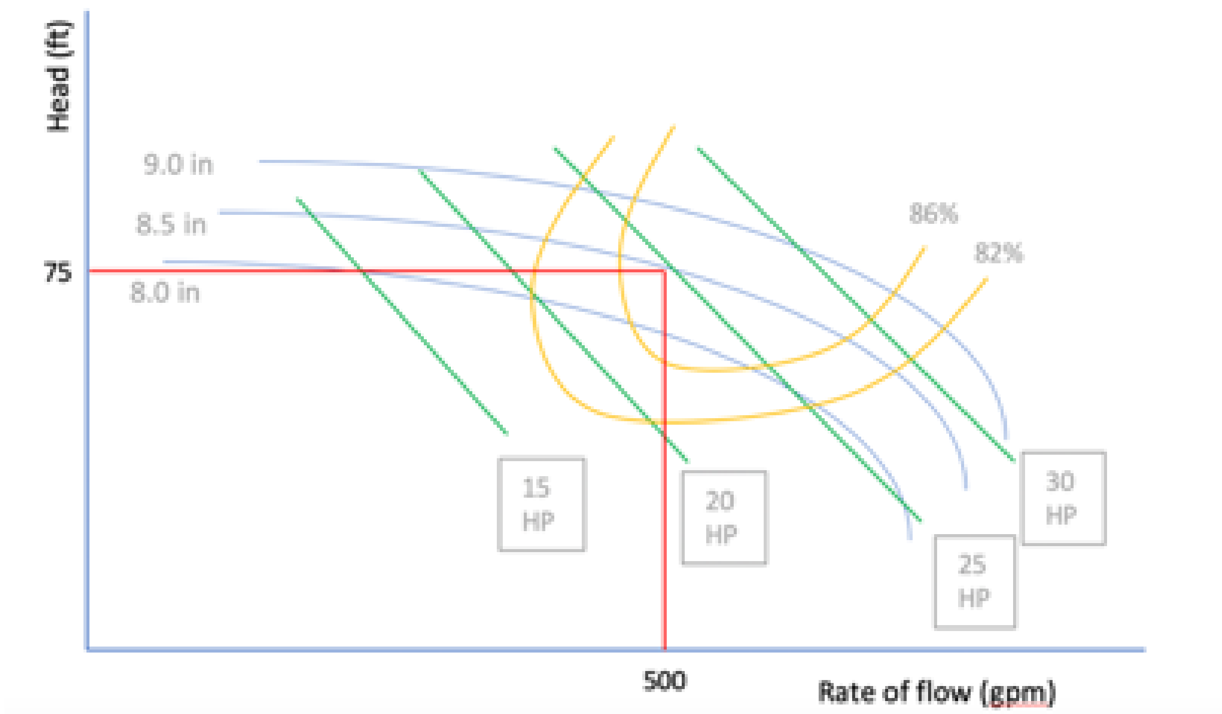
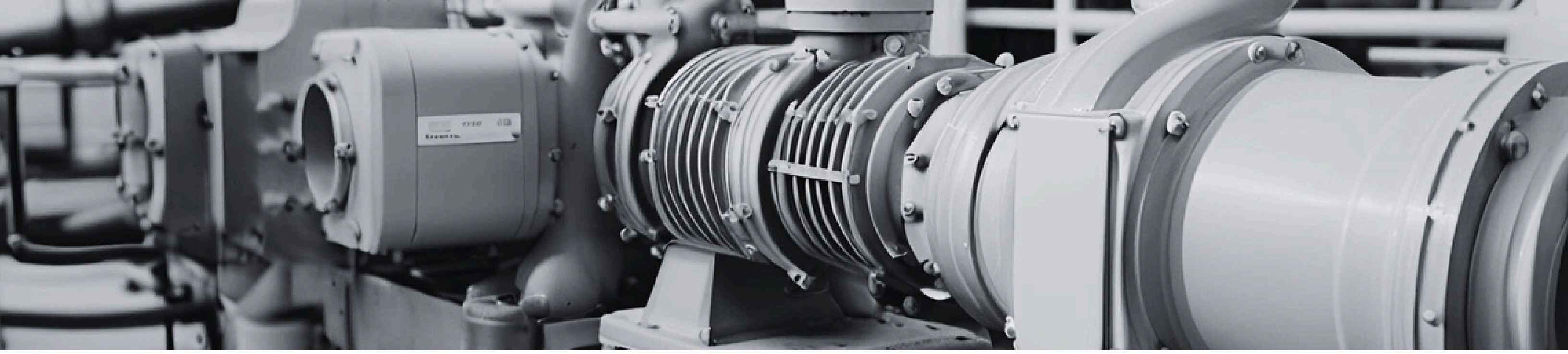


Figure 2: Sample Pump Curve
Courtesy: Load Controls, Inc.



By leveraging the power sensor data already captured, the pump manager can compare the original HP demand expectations with the measured, or actual HP requirements. The difference between the original theoretical value and the measured HP value offers insight into process improvement.

In the case where the actual HP measured is much less than the specified HP of the motor, it may be oversized. This may be due to several factors including:
· Addition of new pumps in parallel functions or improvements in piping efficiency
· Business or process changes that reduce operating Head or Flow requirements or overall demand
· Overly cautious or conservative initial sizing during the planning process
· Changes in operating temperature or viscosity

Conversely, the motor may be undersized, as indicated by the measured HP at or above specified motor HP. This may be due to process changes over time such as:
· Business or process changes that increased operating Head or Flow requirements or overall business demand
· Changes in operating temperature or viscosity
· Overly aggressive cost savings approach when initially sizing the pump motor
· Increased wear or impending maintenance needs
· Spikes from seasonally high demand that were not originally forecasted

Capturing longer term power data from the pump motor control allows the pump manager to be confident that any changes in motor HP will safely fall within a broad range of operating conditions over the long run. Similarly, comparing this extended duration of power levels among peer pumps aids in highlighting the pumps that are performing similar pumping workloads with dissimilar energy requirements. Both of these approaches will yield a prioritized list of the pumps and motors requiring most immediate and thorough attention during upcoming maintenance intervals.

4) Pump Motor Power 10k/Second: Electrical Signature Analysis for Early Fault Detection

While changes in motor power over time offer important insight into impending maintenance needs, new opportunities for analyzing motor power data have arisen with recent advances in machine learning, networking/IoT and data science. By converting motor power signals and their underlying components (Voltage, Current and Power) from time-based measurements to frequencies, new wave forms are created that represent the 'sound' of the motor power signature. Comparing changes in the baseline signature waveform of healthy motors and pumps over time can indicate the early onset of performance issues and impending failures. These comparison techniques, under the umbrella term of Electrical Signature Analysis (ESA), include Motor Current Signature Analysis (MCSA), Instantaneous Power Analysis (IPA) and Park Vector Analysis (PVA).
While each technique offers unique strengths, all are aimed at early awareness and diagnosis of motor and pump failures such as motor imbalances, stator shorts, rotor breaks, and pump and bearing wear.

Three key benefits of these approaches are:
• **A non-invasive installation**. No changes to the pumping environment are necessary to implement ESA.
• **Highly sensitive**. Impending maintenance issues can be identified much earlier than other approaches.
• **Location flexibility**. Unlike vibration sensors, the ESA solution can be installed in climate-controlled motor control cabinets away from environmental hazards.

Conclusion

Many pump system managers implement pump motor power sensors and controls as a highly effective form of insurance against downtime. The same data that these controls use to keep pumping equipment protected can be leveraged across varying time frames to provide important insights into the presence of early faults, pump and motor efficiency, maintenance needs, and overall pumping system health and energy requirements.

[1] Stevens, Micheal T. (1996). Mag Drive Pumps: Why They Work - How They Fail. Texas A&M University. Turbomachinery Laboratories. Available electronically from http://hdl.handle.net/1969.1/164153.

[2] Gunn, Neal (2020) How Long Can I Run My Pump Dry? Pumps and Systems, September 2020. https://www.pumpsandsystems.com/how-long-can-i-run-my-pump-dry

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About Load Controls

Load Controls was incorporated in 1984 with the vision of providing motor power sensors to the process manufacturing world. Decades later, we remain committed to that vision, with an ever-expanding product portfolio, a growing base of more than eleven thousand satisfied customers, and more than 170,000 controls installed to date. Load Controls has a track record of supplying and servicing motor monitoring solutions to the world's leading organizations. Currently, our sensors and controls are used by:

- 9 out of 10 of the world's largest chemical processing firms
- 9 out of 10 of the world's largest pharmaceutical companies
- 7 out of 10 of the world's largest paper and pulp processing manufacturers

We sell our products directly around the globe, and through pump equipment distributors and electric component supply partners. We are based in Sturbridge, Massachusetts, in our own "mini-mill" brick building, a modern replica of the many red brick buildings that dot our regional landscape.

We manufacture all our controls and sensors here in Massachusetts. In 2022, we earned the ISO9001:2015 Certification, a testament to our continued quality management in the design, manufacture, and service of our 100% US-made industrial sensors and controls.