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PUMPS & SYSTEMS

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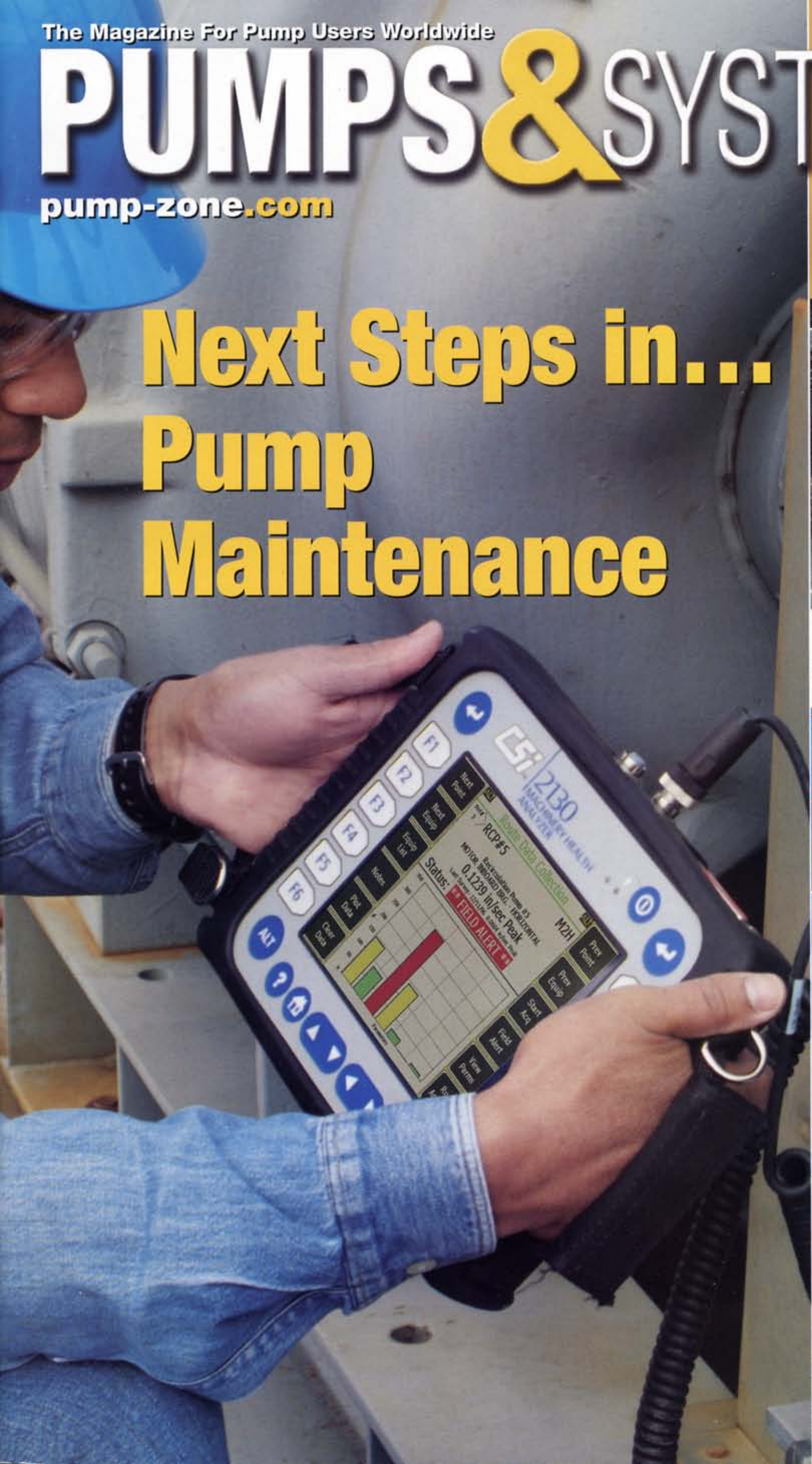
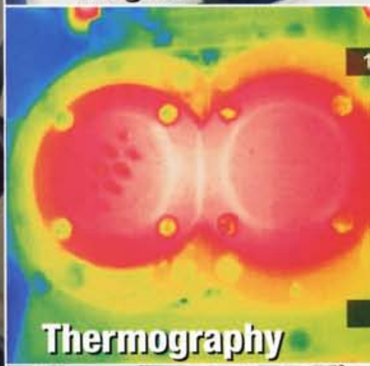


Next Steps in... Pump Maintenance

Controls & Monitoring

Lubrication

Vibration & Alignment



Thermography

Other Solutions

A dual trip switch monitor.

by Joseph D. Warrender, Warrender, Ltd.

Digital power monitoring devices are widely accepted and continue to provide pump users with a relatively low cost, non-invasive and precise means of safe-guarding pumps of all types against adverse operating conditions, including (but not limited to) dry running, dead-heading or operation below minimum flow, cavitation or "pseudo-cavitation" (i.e., entrained air, suction leak, vortex, etc.), and internal obstruction.

Power Monitor vs. Ampere Sensors

Current or ampere sensors are most effective under high load power conditions and offer minimal protection under low loads. Amp sensors can be a useful secondary monitoring system, yet should not be a sole source of protection. True power monitors combine amps, volts and a power factor to provide linear reading across the entire range. This is particularly useful when dialing in critical settings to sense cavitation or spent filter elements in a filtration system.

Dynamic Pump Parameters

Centrifugal Pumps

Centrifugal pumps are designed for *high flow* and draw maximum power (high load) in high flow conditions, and minimal power (low load) near the lowest flow point. Therefore, *high load* sensors can detect:

- Excessive flow
- Run-out condition due to insufficient head (e.g., overstated head, "fudge factors," discharge pressure drop, etc.)
- Initial onset of cavitation (e.g., low NPSHa, low suction head, vaporizing liquid, etc.)
- Flow restriction (e.g., plugged *suction* filter or strainer, partially closed *suction* valve)
- Pseudo-cavitation (i.e., entrained air, vortex, suction leak, etc.)
- Interference or obstruction within the pump

Alternately, *low load* sensors can detect:

- Minimum flow
- Dead-heading
- Flow restriction (i.e., plugged *discharge* filter or strainer, clogged spray nozzles, closed *discharge* valve, etc.)
- Dry running
- Vapor lock

Turbine Pumps

Regenerative turbine pumps are *high head* designs drawing maximum power (high load) under high head near the lowest flow point, and minimum power (low load) under high flow conditions. Therefore, *high load* sensors can detect:

- Minimum flow
- Dead-heading
- Flow restriction (e.g., plugged *discharge* filter or strainer, clogged spray nozzles, closed *discharge* valve)
- Internal restriction or obstruction within the pump

The *low load* sensors can detect:

- Excessive flow

- Run-out condition due to insufficient head (e.g., overstated head, "fudge factors," discharge pressure drop, etc.)
- Initial onset of cavitation
- Flow restriction (e.g., plugged *suction* filter or strainer, closed *suction* valve)
- Pseudo-cavitation (i.e., entrained air, vortex, suction leak, etc.)
- Dry running
- Vapor lock

Detecting Cavitation

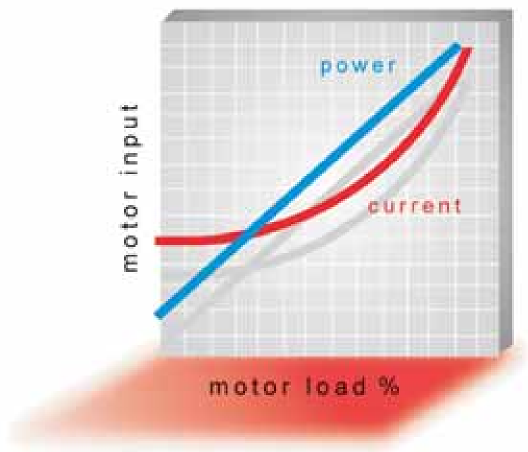
A common misconception regarding cavitation is that detection as a low load is indicated. In actuality, in most cases, the initial phase of cavitation in a *centrifugal* pump is detected as a high load signal from a closely adjusted high load sensor.

Stable flow conditions correspond to constant motor torque, while cavitation involves variable torque from the surging impeller action as it hits pockets of gas. The variable torque applied to the motor results in power spikes. Eventually, severe undetected cavitation will result in diminished flow and/or a total vapor lock and a low load signal; at this point severe pump damage may have already occurred.

The aforementioned guidelines are exactly the *opposite* for regenerative *turbine* pumps, because of the inverted power curve and high head performance vs. high flow centrifugal pump characteristics.

Positive Displacement Pump Parameters

Positive displacement pumps (e.g., rotary gear, lobe or vane, eccentric screw, oscillating piston, progressive cavity, etc) have an inverted power curve similar to regenerative turbine pump designs, but are protected primarily from dry running with power monitoring as the reaction time delay in a dead-head mode may not prevent over-pressurization from an instantaneous pressure spike. Therefore, pressure relief systems are still required.



Start-Up Procedures & Settings

Various mode settings should be carefully reviewed to match system requirements. For example, the start-up delay setting should be adjusted to allow for proper flooding and air evacuation in the piping; extended priming time is required for self-priming pumps. The reaction time, and high and low load trip settings should also allow for process variations (including the minimum NPSHa) to protect the pump while circumventing problematic "nuisance" signals.

Various designs are available that include single, dual or multiple trip points (with or without a 4-20 mA output), and units with advanced preprogramming that automatically set operating limits based upon start-up load conditions.

Predetermining an appropriate minimum and maximum flow or pressure range (factoring in specific gravity and viscosity) to achieve adjusted values and the percentage of power, prior to adjusting the trip switches, is advisable to cross check settings.

Units with auto-preset capability may require reprogramming to sense cavitation or a runout condition. Auto programming at start-up in an unstable condition (e.g., cavitation, "pseudo-cavitation" or insufficient head) will not protect against cavitational pump damage.

Example Monitor Set-up

(for units without the auto preset or for verifying auto presets)

Centrifugal (3 x 2 x 6) pump transferring 50 percent sodium hydroxide (1.53 s.g.), 225-gpm @ 150-ft TDH with a minimum flow of 50-gpm (@ 165-ft) and a maximum flow setting of 250-gpm (@ 128-ft).

Low load setting (maximum pressure) =

165 ft ÷ 2.31 x 1.53 = 109.29 psig

Normal condition (normal pressure) =

150 ft ÷ 2.31 x 1.53 = 99.35 psig

High load setting (options):

a) High load cavitation setting = Normal high load + 3 percent
b) High load setting (minimum pressure based upon BEP +10 percent)
c) High load setting (minimum pressure based upon minimum NPSHa or maximum HP)

The start-up delay and reaction timers can be adjusted to within 10 to 15 seconds (or higher). Upon start-up, under normal operating conditions, dial the high load trip switch until LED activates, check the percentage of load, and open the setting by a few percentage points. Then regulate or throttle a discharge valve to the maximum pressure setting (or minimum flow) and adjust the low load trip switch until the LED activates and then open the valve to the normal position.

Monitoring Filters

Power monitors are ideal for sensing spent filter elements across a filtration vessel. Filter media life is typically inversely proportional to the start-up pressure drop across the elements * (i.e., each point that the pressure drop doubles, filter life diminishes by approximately 50 percent). Therefore, this method can determine the maximum pressure drop that coincides with spent filters and appropriate replacement intervals.

The pressure differential across the media must be differentiated from the pressure drop across a charged filtration vessel. (i.e., calculate the pressure differential across an empty filtration vessel prior to installing the elements) at start-up.

VFD Controllers

Power monitors are usually installed ahead of VFD controllers and are less protective as the load diminishes (e.g., centrifugal or turbine pumps at reduced RPMs). New designs are being incorporated into packaged VFD starter systems with dynamic set points, as opposed to the less effective fixed set points.

VFD, monitor and starter packaged systems.

Process Variations

Power monitors are best suited to systems with fairly consistent fluid conditions. System requirements involving varying specific gravities, viscosities and temperatures often require opening load settings to a marginally effective range; however, in such cases dry-running can still be detected.

For example, pumping systems in tank farms often pump various types of liquids and corresponding fluid properties. Therefore, if fluid conditions vary significantly, flow monitoring may be necessary or possibly preferred (i.e., should settings be adjusted out of the effective range).

Secure *Your* Settings

A lockout feature provides an added margin of safety to ensure critical settings are not readjusted beyond the effective range after a start-up.

Working example: An arduous refinery service involving Incoloy-825 mag-drive turbine pumps delivering 80 percent spent sulfuric acid to an incinerator at a rate of 25-gpm @ 350-psig were protected against obstructed suction piping (i.e., remnants of fire blankets), a non-symmetrical suction manifold, clogged spray nozzles and lack of a pressure relief system. Fortunately, the starter panel was secured with a pad lock despite evidence of a boot print! ■

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