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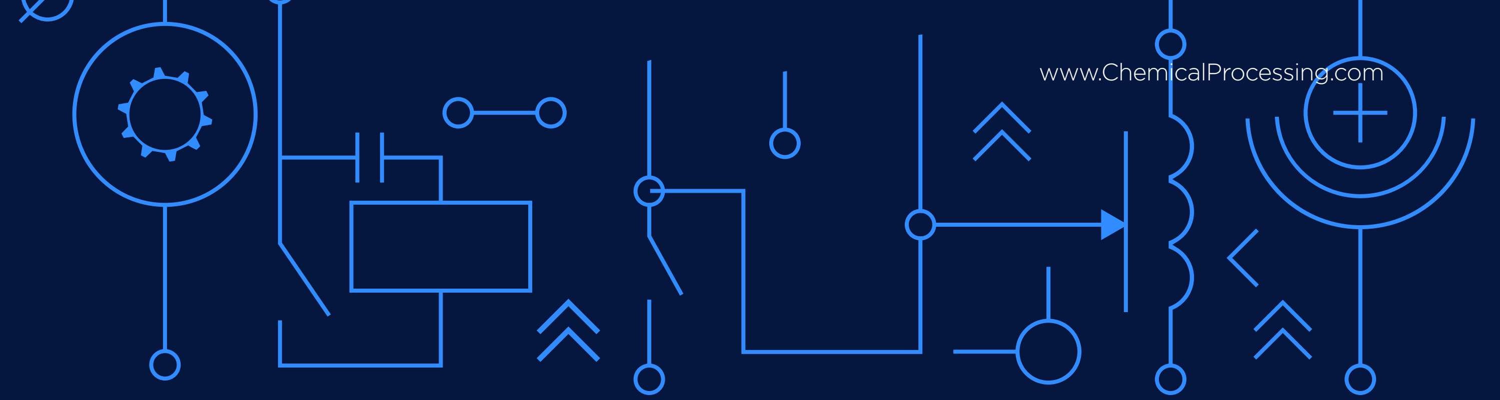

Perform a Proper Pre-startup Safety Review

Protect personnel and processes by conducting a thorough review before operating new or updated units

By John C. Wincek, DEKRA Process Safety

A pre-startup safety review (PSSR) is a critical element of the process safety management (PSM) program mandated by the United States Occupational Safety and Health Administration (OSHA). However, due to time constraint and budget pressures, the temptation to rush or completely neglect the PSSR often exists.

OSHA implemented the PSM program in 1992. It spelled out the need for a PSSR in 29 CFR (Code of Federal Regulations) *1910.119(i)*:

1910.119(i)(1) — The employer shall perform a pre-startup safety review for new facilities and for modified facilities when the modification is significant enough to require a change in the process safety information.

1910.119(i)(2) — The pre-startup safety review shall confirm that prior to the introduction of highly hazardous chemicals to a process:

1910.119(i)(2)(i) — Construction and equipment is in accordance with design specifications;

1910.119(i)(2)(ii) — Safety, operating, maintenance, and emergency procedures are in place and are adequate;

1910.119(i)(2)(iii) — For new facilities, a process hazard analysis [PHA] has been performed and recommendations have been resolved or implemented before startup; and modified facilities meet the requirements contained in management of change, paragraph (l).

1910.119(i)(2)(iv) — Training of each employee involved in operating a process has been completed.

The PSSR frequently is the last line of defense before bringing an updated or new process online to ensure:

- It has been designed properly.
- The equipment and process information is complete and available.
- The equipment is installed per the design specifications.
- A PHA has been conducted and associated, documented recommendations have been addressed.
- Documented safety, operating, maintenance and emergency procedures are adequate and complete.
- All training of operations personnel has been finished.

One item not specifically spelled out in this regulation but probably included in the intent for equipment is the safety instrumented system (SIS) with associated distributed control system (DCS), programmable logic controllers (PLC) and stand-alone digital or analog controllers and alarm systems. It provides alarms to alert operators if the process is starting to get out of control and interlocks to take certain actions, intervene or even stop the process, if necessary. Ensuring the automated valves, associated process instrumentation, alarms and interlocks are active and functioning as designed can require significant time and effort before starting a new or updated process or restarting a process after a major shutdown.

INCIDENTS UNDERSCORE IMPORTANCE

In March 2005, the BP Texas City refinery suffered a major disaster that killed 15 and injured more than 170 others. (For details, see the report issued by the U.S. Chemical Safety Board (CSB), http://bit.ly/2RumKXU.) BP hadn't properly conducted safety critical checks. The CSB investigators found an inoperative pressure control valve, a defective high-level alarm and an uncalibrated sight-glass level transmitter as well as portable trailers with non-essential personnel located too close to the process.

In incidents at two other sites, improperly conducted PSSRs of process control and system settings led to equipment and process damage with financial and business impact. Fortunately, neither caused deaths or injuries.

In the first event, equipment manufactured in Europe and shipped to the United States had a 50-Hz motor setting remaining from preliminary testing overseas. That setting should have been changed to 60 Hz for U.S. operations. Failure to alter the setting caused the motor to run slower and resulted in a process shutdown due to high temperature. Operational steps taken while cooling the process led to a propagating fireball explosion that caused extensive damage to the outdoor process equipment and some siding on the building.

In the other incident, a manufacturing operation replaced a circuit board, treating this as an in-kind change, although the board actually was an updated version. The site didn't conduct a PSSR and, thus, didn't uncover that several critical interlocks weren't operational due to the board replacement. The result was a damaged shaft, plus repair and replacement cost, and the associated lost production time (8–10 weeks).

Properly performed PSSRs would have prevented these three events. Ensuring a thorough PSSR requires both qualified employees and knowledgeable, safety-minded management. The PSSR also should get reviewed and approved before allowing processes to be brought online or restarted.

Effectively conducted PSSRs can prevent incidents and the resultant harm to personnel, equipment damage, and loss of production and profits. According to OSHA, the ultimate responsibility lies with plant or facility management to ensure a PSSR is properly conducted before a covered process is started.

Unfortunately, some common errors often undermine efforts:

- failure to conduct a PSSR after process modifications or a prolonged equipment outage;
- assembling a team without the necessary knowledge and skills to adequately perform the PSSR;
- skipping or forgetting parts of the PSSR needed to ensure the process is completed and ready to start;
- omitting critical safety features from the review or not checking them for proper installation and operation; and
- lack of appropriate approval steps for the PSSR before proceeding to start or restart the process.

Following good practices can help ensure a PSSR is performed properly. Five key ones are:

1. Assign a leader to be in charge of the PSSR team. This person should have sufficient authority to delay the startup if the team identifies a significant deficiency. Given that such a delay could lead to a serious financial loss, very strong pressure to allow a deficient process to start up may arise. So, the leader must have the personality, skills, knowledge, determination and organizational authority to resist such pressure.

2. The leader should assemble an appropriate multi-disciplined team of personnel (design and construction, engineering, instrument and controls, maintenance, operations, safety and supervisors) to complete the PSSR and the additional follow-up activities.

3. The team should use a checklist or other suitable PSSR form to verify all required parts of the PSSR are completed.

4. Ensure the team understands all the process equipment subject to the PSSR. This should include tanks, vessels, reactors, mixers, connecting piping, etc., as appropriate, as well as the associated instrumentation and controls, including the DCS or PLC.

5. If necessary, consider using third-party contractors and consultants to supply necessary information or technical expertise on the equipment or process under review.

A CRITICAL STEP

A PSSR may resemble a hazard analysis, although it's not aimed solely at identifying new hazards. Rather, the PSSR is intended to ensure the plant or process about to be started is safe and operable.

Don't treat a PSSR as just an exercise in filling out a form or ticking boxes on a checklist. Sometimes, it's necessary to perform nondestructive or other appropriate tests on the equipment, instrumentation and control systems in the field before starting a process. You must do whatever is required to have high confidence the equipment and associated instrumentation and control systems function properly as designed and intended, and critical safety devices can't be bypassed.

A PSSR mainly serves for verification, not the identification of new hazards. It provides the last opportunity for the team associated with a project to ensure the possibility of an unsafe condition doesn't exist before the process goes into operation and potentially hazardous chemicals are introduced. In addition, it enables the team responsible for the design, operation and maintenance of the process, including facility management, to check — before starting up — that effective procedures have been written and the operators and maintenance personnel have been trained on the process. ●

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Online Monitoring Optimizes Polymerization Processes

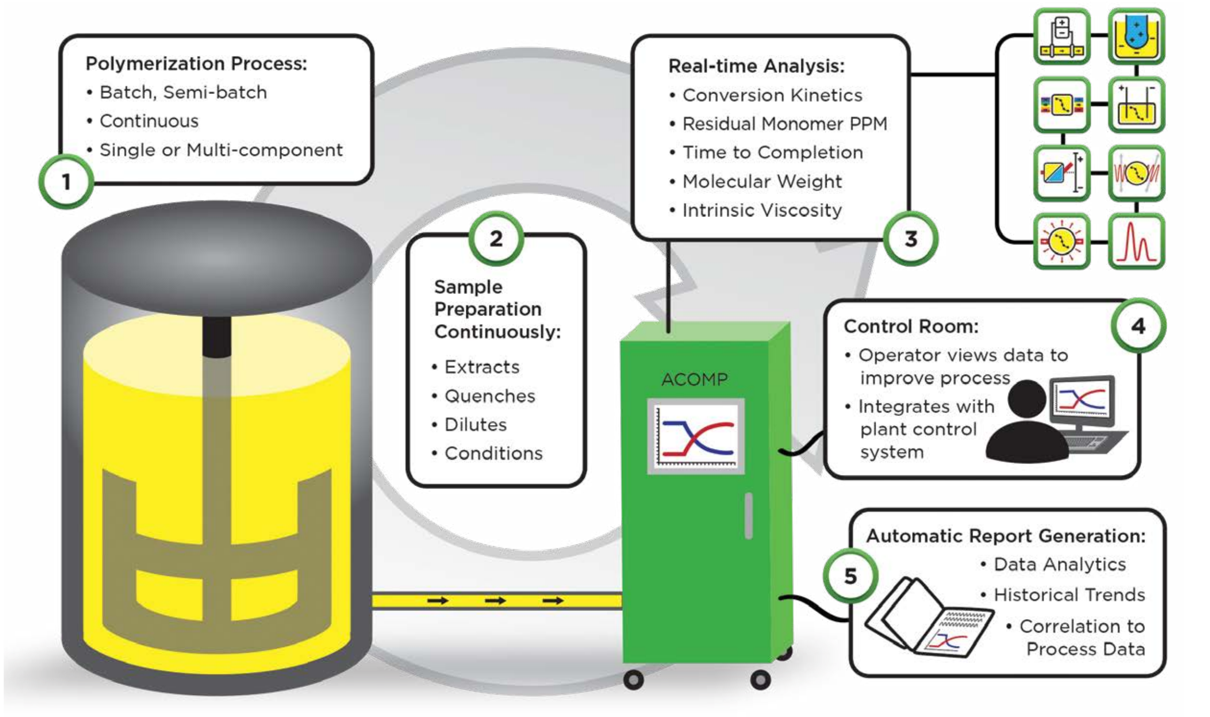
Plant enhances product quality and reduces cycle times

By Grant Heard and Scott Meikle, Nalco Water, and Alex W. Reed and Michael F. Drenski, Fluence Analytics

While makers of commodity polymers generally rely on high-throughput continuous processes, many specialty polymer manufacturers use batch processes. This meets customer requirements for flexibility in making a wide range of products on time without changes to the plant infrastructure. In addition, specialty polymer manufacturers regularly develop product recipes featuring new properties; these are often produced using industrial equipment in a relatively short period of time.

Nalco Water, an Ecolab company, is a world leader in high-value polyacrylamide (PAM) polymers and other products and services for industrial and municipal water treatment as well as other applications. Many of these products are made at Nalco's facility in Garyville, La. In some applications of PAM, such as in cosmetics or contact lenses, human contact with the product may occur, necessitating very tight control of residual monomer specifications.

A common issue when producing polymers using batch processes is knowing the exact endpoint at which to stop the reaction and begin the next run. Specialty polymers like PAM must adhere to rigorous quality specifications, which include safety-related parameters like residual monomer (restricted to ppm levels) and in-use properties like viscosity. Without a way to directly monitor what's happening in the reactor, checking of these specification parameters must take place in the quality control lab after the reaction



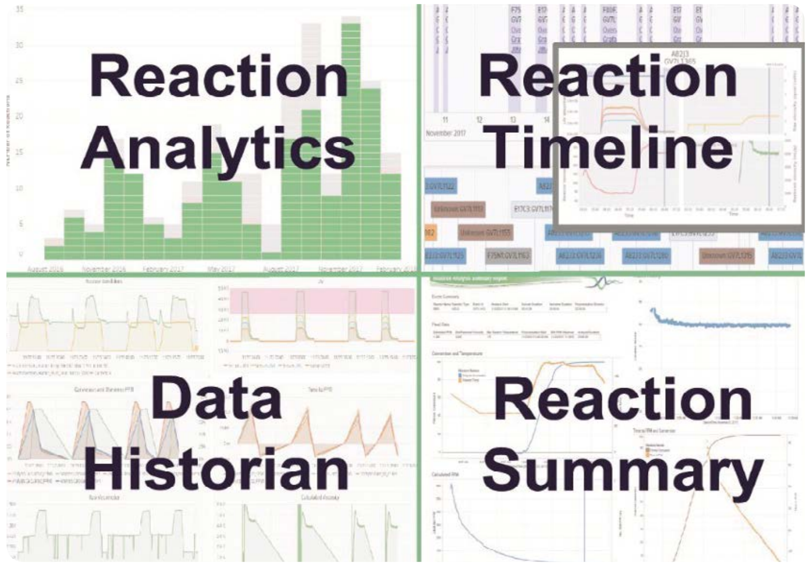
POLYMERIZATION MONITORING
Figure 1. System analyzes a small liquid sample using advanced characterization techniques.

is over. To avoid off-spec batches, many plants usually adopt a conservative approach — running the reaction much longer than necessary, consuming energy, operator time and equipment availability. Clearly, a more-dynamic approach to monitoring each batch is desirable due to changes in day-to-day conditions from a number of variables including feedstocks, personnel, temperatures and equipment performance.

So, what if a person could “see into the reactor” and track key parameters as the reaction occurs? That’s exactly what ACOMP (which stands for Automatic Continuous Online Monitoring of Polymerization reactions), a smart manufacturing system produced by Fluence Analytics, does.

ACOMP is an integrated hardware/software analytical tool that continuously takes a very small sample of liquid from the reactor and analyzes it using advanced characterization techniques (Figure 1). Ultraviolet absorption or differential refractometry characterization determine the continuous polymer concentration. This concentration enables characterizing the weight average molecular weight and reduced viscosity of the polymer in real time throughout the entire polymerization process.

ACOMP, which is tied into the distributed control system for increased plant connectivity, generates automated reports detailing initial reactor conditions, rate of conversions, conversion levels, time to target conversion, and product quality values for each polymerization (Figure 2). These reports are stored in a database, allowing for quick historical reference; they identify ways to improve efficiency and reduce variance not only of product quality but also of reaction process time from batch to batch. This enables operators to tighten up standard operating procedures (SOPs), ensuring that each polymerization follows "golden batch" kinetics.

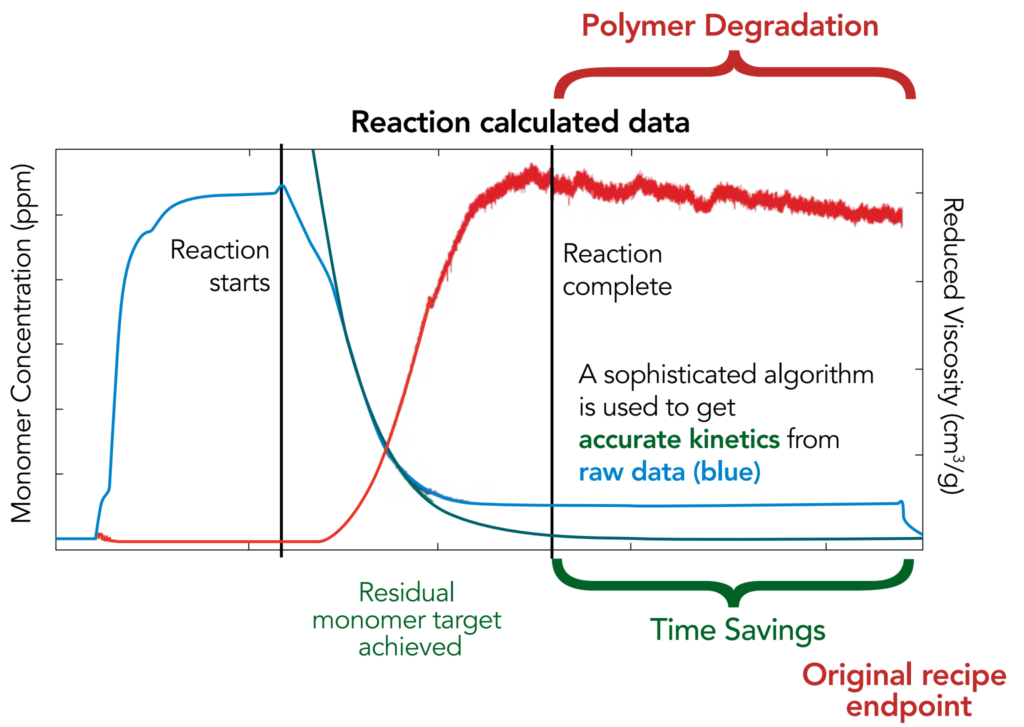


DASHBOARDS
Figure 2. Tool provides a variety of analytical, operational and historical data.

ADOPTION AT PLANT

In 2013, Fluence Analytics began a dialog with Nalco to discover its needs and determine how ACOMP could meet them. Following some initial research in cooperation with Nalco's plant and R&D professionals, the two companies decided to pursue a joint technology development project. The result was the first-ever industrial ACOMP system installation — on one of Nalco's inverse emulsion PAM reactors in Garyville in October 2014. Nalco's engineering team worked with Fluence Analytics to design and install a fast loop for an ACOMP sampling point, specify required utilities and tie-ins into the process and control system, and develop SOPs for startup and training. All startup procedures and personnel training were executed post system startup with operators utilizing the ACOMP system through the plant control system to successfully monitor reactions.

During this time, global capacity for PAM was very tight due to the U.S. fracking boom. (PAM is used to enhance oil recovery



REACTION DATA
Figure 3. Accurate real-time data have led to a notable reduction in cycle times.

in hydraulic fracturing.) Nalco's visionary support and willingness to explore new smart manufacturing technologies by partnering with a startup paid dividends. Because ACOMP allowed Nalco to "see inside its reactor," the company was able to reduce its production batch cycle times for a wide range of its products. After startup, reactions were monitored to understand the endpoint of the batches (Figure 3). Following the monitoring of more than 100 reactions, it was calculated that ACOMP enabled a 15–20% reduction, on average, in batch cycle times across Nalco's PAM products manufactured in one reactor. ACOMP was able to expand monitoring to almost all products made in the reactor. After significant parallel use, operating and utilizing ACOMP data for cycle time optimization eventually became a plant SOP.

This 15–20% cycle time reduction directly translates to increased capacity in the reactor as well as time, labor, overhead and other savings. In addition, use of ACOMP improves polymer quality. Nalco Water prides itself in distinguishing its offerings in the marketplace with unmatched service and quality. ACOMP has helped the company advance that cause.

Currently, Nalco uses ACOMP not just to monitor batches for existing products but also for the introduction of new grades. With ACOMP, it's possible to see what's occurring in real time, so every run is optimized.

In 2016, Nalco purchased a second-generation ACOMP unit for another production line at Garyville (Figure 4). Even when maximizing reactor capacity isn't an overriding issue as it is in boom times, ACOMP still saves energy and overtime, providing additional benefits. Based on feedback from Nalco, the second-generation ACOMP included important features such as autonomous operation tied directly to process operations (previously the operators had to start and stop ACOMP's measurements) and the ability to physically locate the unit close to the reactor, important for addressing shop-floor space constraints. The second-generation system has been running continuously with average on-stream efficiency exceeding 95%.

ONGOING DEVELOPMENTS

Nalco and Fluence Analytics currently are exploring the economics of installing ACOMP at other facilities. The companies also are teaming up to leverage onboard ACOMP analytics tools and Nalco's internal data-analytics initiatives to mine the ACOMP data and explore the

SECOND GENERATION SYSTEM
Figure 4. Unit installed at Garyville, La., plant includes several significant enhancements.

impact on product quality control. This will be a key next step, which is supported by ACOMP's continuous monitoring of intrinsic viscosity, a molecular weight measurement important for performance in certain applications. Enhancing the process through data-driven dynamic quality control with ACOMP measurements will further improve the value of the system as a complete tool for overall process optimization — especially when combined with the already demonstrated cycle time benefits.

One ACOMP run can generate information that otherwise would take several runs with post-analysis.

Fluence Analytics continues to upgrade and optimize ACOMP. The third-generation ACOMP, released at the end of 2017, can process a higher temperature flow through the detectors. While not necessary for PAM, this leads to better quality data for high molecular weight polymers like synthetic rubbers. A recently raised round of venture capital has enabled the company to offer a paid demo program in which potential customers can use ACOMP for several weeks to demonstrate the value of real-time ACOMP data in their applications.

ACOMP has been applied to more than a dozen different polymers in processes ranging from solution and emulsion to high-viscosity bulk reactions. In addition to applications in industrial production, ACOMP also has been used to speed up polymer product development in the laboratory. One ACOMP run can generate information that otherwise would take several runs with post-analysis. In November 2017, Fluence Analytics shipped such a lab ACOMP unit to a leader in biochemistry that's developing new high-value products for life science applications. With more application data and the newly launched demo program, ACOMP now has attracted interest from more than 30 global companies.

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Promptly Address Control Valve Issues

Testing process helps screen for issues quickly without the need to pull equipment

By Kyle Barna, Fluke Corp.

Valves open and close proportionally and vary the degree of travel depending on a variable 4–20-mA signal applied to their input. Many valves have a feedback signal that shows the actual position as a percentage of open/close. This output can be a 4–20-mA signal or a digital HART variable that represents 0 to 100% of control valve operating span.

Also indicative of a valve's performance is the pressure the valve needs to move to a desired position. For example, a valve may be programmed to know that if 12 mA is applied, it should be 50% open. Smart electronics will control what essentially is a smart pressure regulator to increase or decrease pressure as needed to move the control element to the desired position (Figure 1.).

Figure 1. Smart electronics will control what essentially is a smart pressure regulator to increase or decrease pressure as needed to move the control element to the desired position.

Applying a varying mA signal while also monitoring the output milliamp — or percentage of travel signal — will tell you whether a control valve is operating correctly over its range. Similarly, monitoring and recording the pressure applied to the final control element while varying the input 4–20-mA signal to the valve is a key test to identify whether a valve is sticking (see Table 1).

If a valve is working correctly, the relationship between pressure and mA — or the valve's position — normally is linear. If additional pressure is required, it might be that the valve is sticking, which will be shown if measurements are logged and graphed. Recording those signals documents the valve's performance. This documented test and results often are called a valve's "signature."

- **3.8 mA** — valve should be **hard closed**
- **4.0 mA** — valve should remain **closed**
- **4.2 mA** — valve should edge **slightly off its seat**
- **12 mA** — valve should be at **50%**
- **19.8 mA** — valve should be **near full open**
- **20.0 mA** — valve should be **fully open**
- **20.2 mA** — valve should be at **hard open** (resting on stop)

VALVE OPERATION
Table 1. This guide shows the typical expected operation of a valve when a milliamp signal is applied.

ON-VALVE INDICATORS OFFER ROUGH MEASUREMENT

Valves typically include simple manual indicators that give an approximation of the percent of travel for a setting when in operation. However, that indicator does not show how the valve will operate under dynamic and changing conditions, and its accuracy isn't assured.

"The indicator on the side of the valve might tell you it's at 50%, but do you really know it's not 51% or 49%? You can't tell," said Jim Shields, product manager for Fluke Process Tools. "And, in many processes, that could make a difference."

The most sophisticated valve performance tests require removing the valve and testing its performance on a "valve prover." These expensive testing devices are out of range for many plants and shops. Other testing is possible with specialty HART test instruments, but they can be difficult to set up and use.

Indeed, a technician working with an assistant for a full day can test approximately eight valves accurately, or about one an hour. That includes having the assistant pull the valve and give it to the technician at a bench. The technician then runs the tests while the assistant does all the mechanical tasks. That's roughly two labor-hours to test one valve.

LOOP VALVE TESTER
Figure 2. This loop valve tester offers a variety of tests, including a signature test that can quickly assess a proportional smart valve's performance.

AUTOMATING THE TESTING PROCESS

A new class of loop calibration tools can screen valves quickly to determine whether they are working properly, saving time and helping prevent unneeded pulling of good control valves from their processes. This latest generation of tools is designed to make expert workflows more accessible to technicians of all skill levels while still offering the range of capabilities expected from a process loop calibration tool.

These calibrators offer several fully automated tests, including a signature test (Figure 2). This test assesses a proportional smart valve's performance and often can be accomplished in as little as five minutes. Signature tests provide an easily understood status check on the valve — good, marginal or bad.

It's advantageous for technicians to get comfortable with the tool and with running the tests, explains Shields: "You can send the lesser skilled instrumentation technician out to test the valves and determine whether a specialist needs to be called in. You're not pulling the valve, which, like pulling a motor, is a lot of work."

After removing control wires and connecting the calibrator's test leads, the signature test ramps the milliamp signal automatically from 4 to 20 to 4 and records feedback from the valve to determine whether the valve moves properly.

ANALYSIS SOFTWARE
Figure 3. Consider a calibrator that can record the data and upload it to application software for further analysis.

It also records the pressure applied to the valve control element from 4 to 20 to 4 milliamps looking for smooth linear changes in pressure across the band — ascending and descending.

"By profiling the pressure that's being used to move the valve, you can see physical spikes in the amount of pressure required to move it through a point even though the position itself might be fairly close to where it's supposed to be," Shields said.

When the test is complete, you get that valve performance assessment of good, marginal or bad. The calibrator also should record the data so you can upload it to application software for further analysis (Figure 3).

BEST PRACTICE: BASELINE AND TREND

A best practice for keeping valves in great shape is to baseline valve performance measurements when the valves are in a known good state. Because most valves use a 4–20-mA input signal, a test tool with an mA output signal can provide the input mA signal to drive the control valve across its operating range. This new generation of calibrator is well-suited to this practice.

The documentation should take place when a valve is commissioned or after an overhaul. The technician records the valve's signature in the ideal state, plotting the output mA or percentage of span signal versus applied input signal. The information is stored along with the

Some devices installed in safety and shut-down systems should be checked every three months.

time, valve tag number and the date the test was performed. Calibration management software then can be used to manage this information further.

After the valves' baseline performance signatures have been recorded, a maintenance interval for testing valve performance should be established. The interval depends on whether the application is rough service or light duty. Some devices installed in safety and shut-down systems, for example, should be checked every three months.

If the plotted data shows the valve has developed a nonlinear signature or has deviations in the curves, the valve may be developing issues that could reduce performance and longevity. This may require removing the valve for service. An indication that a valve is in "marginal" or "bad" condition also is a signal to either perform the trim on the valve controller or bring in a specialist to determine whether more extensive testing out of the process is required.

ELIMINATING CUMBERSOME TEST ROUTINES

Proportional smart control valves play critical roles in process industries. Assessing valve performance accurately, however, can be a cumbersome routine that often involves substantial downtime as well as pulling the valves from the line. With the new generation of calibrators, technicians can screen valves quickly and easily while they are in operation, eliminating the need to remove good valves from their processes, thereby, keep equipment running.

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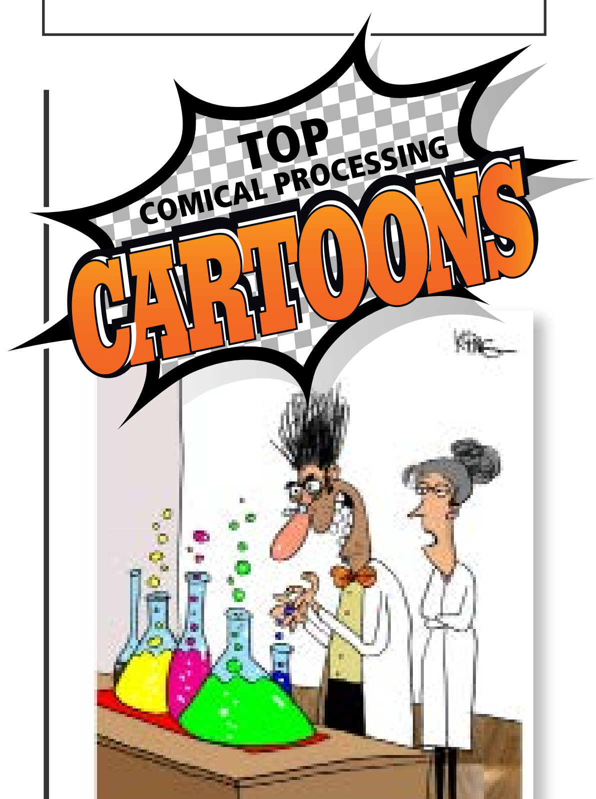

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