Control Elements

ADVANCED VALVE AND ACTUATING TECHNOLOGY

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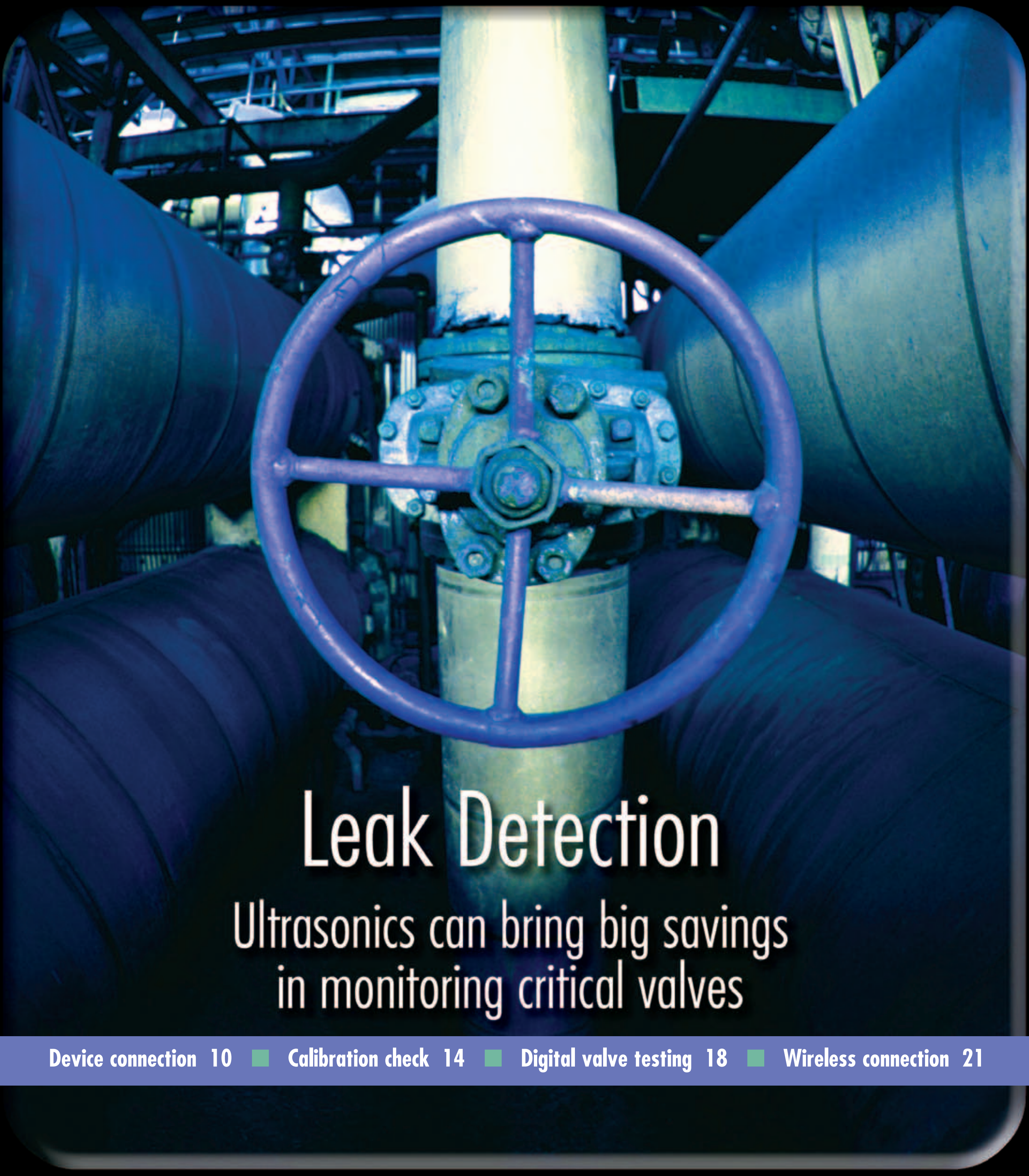


Leak Detection

Ultrasonics can bring big savings in monitoring critical valves

ISA–The Instrumentation, Systems, and Automation Society

FINAL TEST

Safety valve testing goes digital.

By Riyaz Ali

Major accidents worldwide have raised awareness in improved plant safety, especially in the chemical, refinery, oil, and gas industries.

Growing concerns with safety instrumented systems (a layer of protection) and enforcement of governing industry standards is creating a significant demand for a device that can provide a method for testing safety valve operation without disturbing the process and providing diagnostic information about the final control element.

Safety Instrumented Systems (SIS) consists of sensor, final control element, and logic solver. Final control elements of SIS are not continually moving like typical control valves, but normally remain static in one position and then operate only when an emergency situation arises.

Previous industrial data indicates a major failure contributor to the SIF loop is the final control element.

The typical failures include being stuck in last position and not operating when needed. This could result in a dangerous condition leading to an explosion, fire, or a leak of lethal chemicals and gases into the environment. To ensure the needed reliability and availability of these safety shutdown valves, they need frequent testing.

Unfortunately, the traditional method of testing these safety valves does not provide any internal valve diagnostics. It just allows mechanical movement but does not specifically provide inputs such as: if the valve friction is increasing, process build up is occurring on bearing/shaft area, pressure is decaying, valve torque requirement is increasing, etc. One way to solve those issues is a digital valve controller. Their diagnostic capabilities can dramatically hike the reliability of these safety systems, and at the same time, reduce the risk of spurious trip, unscheduled maintenance, manual laborious test procedures, associated cost, as well as gaining a multitude of additional advantages.

Failure causes

SIS's are dormant or passive. Under normal circumstances, final control elements in these systems are not moving. They remain in one position without mechanical movement and may never see action. Many potential failures of a safety shutdown valve can remain "covet" or hidden, if a valve is not exercised for a long time.

Typical problems associated with SIS valves are:

1) Increased packing friction over time
2) Build up of process fluid material on shaft
3) Seize of shaft in bearing
4) Fracture valve shaft/stem
5) Corroded bearing
6) Broken spring of actuator
7) Permanent set of spring
8) Linkage breakaway friction
9) Slow air exhaust
10) Air exhaust path blocked
11) Spring return actuator dented not allowing valve travel
12) Increased valve break away friction
13) Actuator stem/shaft bent
14) Increased friction of closure element in seal

The main problem of shutdown valves, which represents significant failure contribution to SIS, is difficulties in testing to detect the valve health. Testing can occur offline or online. If the valves need to move to full 100% travel, it can only happen during annual turnaround. Now that a day's turnaround shifted from its normal time frame to a higher time interval because of economic reason, safety shutdown valves remain a big concern for plant safety management.

Not testing shutdown valves affects the SIL (Safety Integrity Level) calculation of the loop, particularly valves that are significant contributors to probability of failure on demand (PFD). An increase in the test interval directly impacts the PFD value in a linear manner.

To try to get around this problem, companies devised methods for testing the SIS valves on-line so they do not have to shut down the process. The typical approach has been to install a bypass valve around each safety valve. By placing the bypass in service, you can fullstroke test the safety valve without shutting down the process. In addition, maintenance is also easier since you can replace a failed valve while the process is on line. Despite these benefits, the on-line bypass approach to testing has a number of disadvantages. Prime among these is the process is totally unprotected while the bypass is in operation. Also of concern is the possibility of the safety valve staying in the bypass position after testing. This would leave the process totally unprotected until discovering the error. Insurance companies that provide coverage to the plant do not find either of these alternatives very attractive.

Over the years, a variety of methods

came about for this type of partial testing. While all of them have a definite risk of spurious shutdown trips associated with them, the mechanical limiting method seems to be the most popular.

Mechanical limiting methods involve the use of some mechanical device, such as a pin, a valve stem collar, or a valve hand jack that will limit the valve travel to 15% or less of the valve stroke.

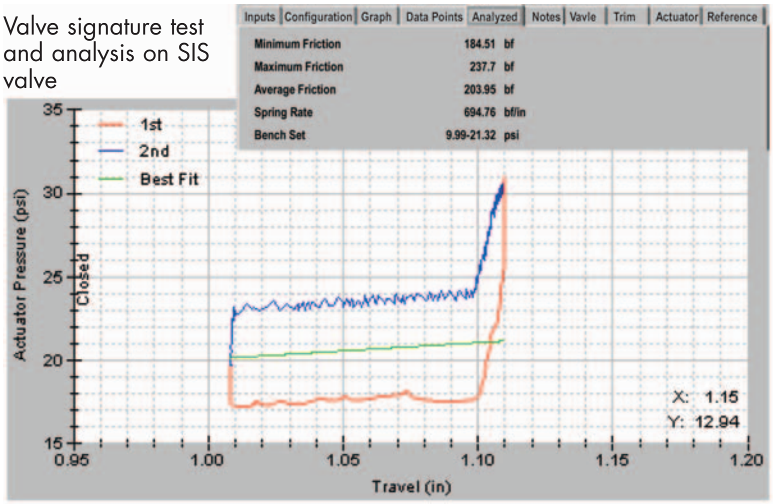
While these mechanical limiting devices themselves are rather inexpensive, the pneumatic test panels used to perform the test are complex and expensive. The testing process must occur manually in the field, and the tests themselves are extremely labor intensive and subject to error. In addition, a major drawback to this method is the safety shutdown function is not available during the test period. Likewise, there is always the possibility the safety valve will inadvertently stay in this mechanically limited condition. Worse yet, you cannot always determine this possibility by a casual inspection. This means the valve could potentially be out of service for an extended period with the operators unaware of the situation.

If testing occurs on on-off shutdown valves (typically solenoid operated), while the plant is in operation, then the tested device should have built in intelligence to avoid potential hazard of spurious trip. It should also be intelligent enough to recognize and differentiate between real safety demand and partial stroke test command. Digital valve controllers have come into play in the SIS loop to not only partially test valve movement but also provide increased safety availability during test and determine the health of the control element.

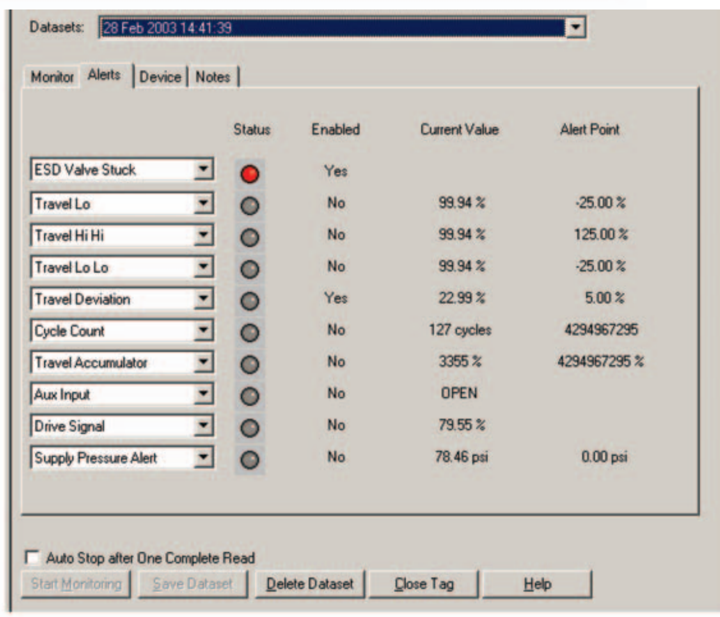
Digital valve controllers or "smart" positioners have proved a remedy to solve the diagnostic issues of safety shutdown valves. These digital valve controllers are communicating, microprocessor-based current-to-pneumatic instruments with internal logic capability.

These digital valve controllers use HART communications protocol to give easy access to information critical to process operation. The digital valve controllers have built in sensors for valve travel, pressure (supply and output pneumatic pressures), and pneumatic relay motion. All these data process in the digital valve controller microprocessor. This allows the digital valve controller to diagnose not only itself but also the valve and actuator to which it is mounted. It enables the plant maintenance group to obtain information in advance for any possible deterioration in the valve, before any dangerous condition can take place.

Valve signature test and analysis on SIS valve



Valve stuck alert



Partial-stroke testing through the digital valve controllers confirms the valve is working without disturbing the process while the plant is running. It also allows more frequent on-line testing since it is simple, less laborious, and reliable. In the past, one of the main concerns had been availability of the safety valve during test to safety demand. With the use of a digital valve controller, on-line testing has greatly relieved worries of non-availability during trip. Since you can program the entire test procedure into the microprocessor, partial-stroke testing can happen automatically with no operator attention required. Companion software can schedule testing automatically. This allows the test interval to be as short as necessary (hourly, daily, weekly) to meet the target SIL values. The testing sequence is completely automatic, eliminating any human errors and possible nuisance trips. However, for safety reasons, the operator should initiate the test sequence locally or remotely with the simple push of a button.

While performing a partial stroke test via a digital valve controller, it collects travel and pressure data during the test periods. You can monitor the valve status and its response to mechanical movement during the test. You can monitor valve performance trends and automatically analyze them after each partial stroke test so you can find potentially failing valves long before they become unavailable. A cycle counter and travel accumulator will show the extent of valve movement.

The results of a signature test can easily determine packing problems (through friction data), leakage in the pressurized pneumatic path to the actuator, valve sticking, actuator spring rate, and bench set. The data points collected during partial stroke test will provide inferred information about initial inertia force, required pressure to actual movement of valve travel, sticking in shaft/bearing area, linkage dead motion, etc. The digital valve controller can save the results of this data for printout or later use. Overlaying the results of the current signature test with those of tests run in the past can indicate if valve response has degraded over time. Analyzed partial stroke test results can provide dynamic error band, dynamic linearity, torque (minimum/maximum), etc. This will enable an early detection of valve related problems. Knowing a problem in advance and correcting it in time will increase valve availability, should a demand arise. It also reduces the amount of scheduled maintenance on the valve because the tests can predict when the valve needs maintenance.

Some digital valve controllers have the capability to alert the operator if a valve is stuck. It can notify key people for critical alerts via e-mail or trigger a pager.

As the digital valve controller begins the partial stroke, it continuously checks the valve travel to see if it is responding properly. If it is not, the digital valve controller will abort the test and alert the operator that the valve is stuck. This will prevent the valve from slamming shut if the valve does eventually break loose. This will avoid spurious trip.

A digital valve controller can provide complete diagnostic health information on the final control element, including the digital valve controller itself. If a valve is found stuck or having excessive friction or leaking air supply, an immediate alert notification will occur. In addition, the digital valve controller can provide complete documentation of any emergency event as well as documentation of all testing. Insurance companies will accept this Safety Audit Documentation for proof of testing. This document can be completely automated, so operator time is not required.

The digital valve controller provides diagnostic as well as positioning information. You can monitor the valve status and response time continuously via companion software.

Finally, should an emergency shutdown demand occur during testing, the digital valve controller will override the test, driving the valve to its safe position. This increases availability of a shutdown valve to plant emergency demand.

You can monitor valve performance trends and automatically analyze them after each partial stroke test so you can find potentially failing valves long before they become unavailable.

A partial stroke test, as the name indicates, will uncover some of undetected failure modes.

The diagnostic coverage factor for mechanical devices (final control element) not only depends on type, size, and geometry, but to a larger extent on process fluid (clean, dirty, and abrasive) and its physical properties (temp, pressure, density, viscosity etc), type of application, history of past operation, failure records, work practice for maintenance, etc. FMEDA (failure mode effects and diagnostics analysis) data from a manufacturer with contribution from end user maintenance records can lead to a reasonable number on diagnostics coverage factor calculation for computing PFDavg (probability of failure on demand) for the final control element.

Digital valve controllers are a great aid to predictive maintenance by providing a valve degradation analysis, which is important for critical valves in safety related systems. This also reduces the amount of scheduled maintenance. While performing the partial-stroke test, if for any reason the valve is stuck, some digital valve controllers will not completely exhaust the actuator pressure. This assures that, if the valve becomes unstuck, it will not slam shut. These digital valve controllers will then abort the test and send an alert signal to the operator warning that the valve is stuck.

If pressure deviation or travel deviation occurs, a digital valve controller will provide an alert notification accessible through either the HART communicator or associated software. This will be an indication of a possible leak in the packing area, a change in friction, a change in pressure, etc, which may need immediate attention or later maintenance of the valve.

The digital valve controller provides a time and date stamp on all tests and reports, which is very important for complying with the requirements of statutory authorities. It also provides the capability for comparing, storing, and interpreting diagnostic data.

Digital valve controllers allow partial-stroke testing while the process is running with no threat of missing an emergency demand. This type of test applies a small ramp signal to the valve that is too small to disrupt the process, but is large enough to confirm the valve is working properly.

While you can gain obvious diagnostics, performance, and safety benefits through partial-stroke testing, additional benefits can occur by using a digital valve controller. Lower base equipment cost occurs with considerable reduction in testing time and a reduced labor requirement through the elimination of expensive pneumatic test panels and skilled personnel presently required for testing. In addition, remote-testing capability requires fewer maintenance trips to the field, as well as the establishment of an automated test routine that can produce great timesaving. CE

Behind the byline

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