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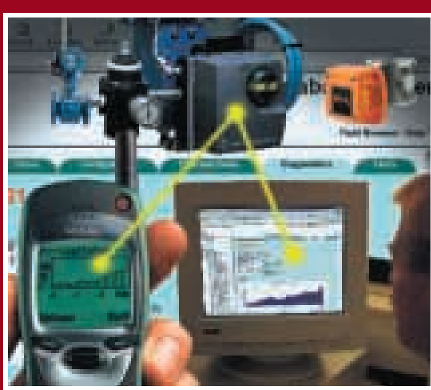






Advances in Valve & Actuator Technologies

CONSIDER Mechanical Partial FOR PROCESS ESD

BY MIKE MITCHELL

There is a storm forming on the horizon for offshore rigs, refineries, and all other industrial process plants that have automated valves in their safety systems. Like the rumble of distant thunder, they know it is coming—but they're just now cranking-up their radar to find out how the storm will affect them. One thing is certain: when this storm finally hits, no plant will remain untouched by its fury....What's causing the storm to brew?

In "the good old days" process plant operations managers had the luxury of shutting down their facility every year or two for what is now fondly remembered as the "maintenance shutdown". This was a period of time set aside to close down production and perform maintenance on the plant's equipment. So the production stream was "turned off" and the maintenance crew was free to disassemble, clean and/or replace equipment. The control systems engineer, safety engineer, and reliability engineers were able to test their process control and safety equipment without the worry of dealing with process flow. That was when companies could devote the time and resources to perform this task in the most efficient and complete manner.

Times have changed, and to succeed in today's aggressive business climate, we must change along with the times. One of the most obvious changes in the process industries in recent years is the demise of the planned periodical maintenance shutdown. Closing down the plant, for whatever reason, also shuts down the revenue stream. The process industries are under incredible pressure to increase revenues and these "shutdowns" of the revenue flow are not acceptable to management and other stakeholders. The result is an emphasis on running industrial process plants on a 24-hour-a-day, 7-day-a-week basis for as many years as possible-without maintenance shutdowns.

RING

Stroke Test Devices & Safety-Related Valves

Among the most critical valves affected by less frequent maintenance are the Emergency Shutdown (ESD) Valves and other fail-safe valves in safety related applications. These valves may typically incorporate a spring-to-fail actuator to stroke a valve in the event of an upset process condition. If the ESD valve does not perform its function to close *(or in rare applications, open the valve)* at the time of an upset event, the consequences to property and life can be catastrophic. [Note: For the purpose of simplifying this discussion, when referring to pneumatically or hydraulically operated ESD and safety valves, the convention of "air-to-open valve, spring-to-close valve, de-energize to trip" will be used].

This new emphasis on continual process revenue generation has led the Occupational Safety and Health Administration (OSHA), insurance companies, other regulatory agencies, and safety engineers to take a fresh look at how this new operating philosophy impacts plant safety. These agencies posed the question to the process plants: If the plant is going to remain operational for an extended period of time, how can we be assured the valve safety systems will function correctly when called upon?

The industry has responded to this question with "accepted industry standards" (essentially self-governing) such as ISA-S84.01 (Application of Safety Instrumented Systems for the Process Industries) and IEC 61508 (Functional Safety Of E/E/PE Safety-Related Systems) to determine acceptable levels of performance of these systems.

This article examines mechanical Partial Stroke Test Devices as a preferred methodology for assuring compliance with new standards. These standards define requirements for Safety Instrumented Systems (SIS) and allow the end user to establish Safety Integrity Levels (SIL) for specific applications. One means of showing conformance is to test all the various SIS components such as solenoid valves, quick exhaust valves, relays, valve to stem integrity, and valve actuator without actually closing the valve.

By the nature of the application, the ESD valve is subject to flowing process fluid. If the ESD were to be full-stroke tested while the plant is operational, the "flow of revenue" *(i.e., process flow)* would come to a halt. One methodology of overcoming this dilemma is to install a bypass valve and piping around the ESD valve. When the bypass valve is open, the ESD valve and its safety system may be fully tested without affecting process flow. This option sounds effective, and it is. However, piping dimensional constraints *(particularly on offshore drilling and production rigs)* and the cost associated with installing a dual system at every ESD valve make a bypass system generally not preferred.

One of the terms associated with these ISA and IEC standards is "partial stroke testing" (Reference ISA-S84.01, paragraph 9.7.5.2.b). A "partial stroke" might be defined as, for example, allowing the safety system to close a valve only 20% (this would be the set point). In that case, all of the control elements are being tested, but obviously the valve never fully closes during the test.

The overall assumption is that a given number of "partial strokes" can be applied as a statistical "credit" against "full stroke tests". Thus, the end user may be capable of either 1) lowering the Probability of Failure on Demand (PFD) of a given SIS by doing partial stroke tests between full stroke tests; or 2) by doing partial stroke testing between full stroke tests, the end user may be able to maintain or lower his PFD and enjoy a greater interval of time between full stroke test intervals.

The background for safety testing has been explained in a previous *Valve Magazine* (See "Getting Closure on Compliance, Putting Valve-Related Safety Standards in Perspective", *Valve Magazine*, Summer 2002 Edition, Volume 14, Number 3). The technical analysis supporting the benefits of Partial Stroke Testing have also been examined in detail at VMA Seminars (Reliability, Safety, Integrity Today, March 7-8, 2002, Houston, TX), and ISA conferences (Safety Instrumented Systems for the Process Industry, May 14-16, 2002, Baltimore, MD) and numerous websites (see, for example, www.iec.ch/zone/fsafety/; www.instrument-net.co.uk/silansi.htm). Thus, it would be redundant to cover that material here.

The purpose of this discussion is to examine the benefits of mechanical Partial Stroke Test Devices as a preferred methodology for functional testing of the SIS when a full stroke of the valve is not practical.

At both the consulting engineer and end user levels, responsibility for process flow control and valve safety systems generally fall under the authority of Control Systems Engineering (Instrumentation) because the valves are automated. Often times this engineering discipline attempts to affect a Partial Stroke through the use of ancillary controls and instrumentation. This often results in making the SIS more complex, expensive, and subject to complicated software programming, installation, and commissioning.

The following criteria should be considered when considering methodology for affecting the Partial Stroke Test of a SIS, including the associated ESD valve:

Keep it a Simple System (KISS)

Because a mechanical Partial Stroke Test Device does not require the addition of extensive extraneous controls, several important user benefits are realized. There are no requirements to add additional power, wiring or control systems to perform a partial stroke function test. The benefit is obviously a reduction in capital cost and system complexity. Secondly, mechanical interlock systems are generally considered a more positive method of achieving the partial stroke. This option is discussed further in "Mechanical Characteristics", below. Lastly, we can make these systems as complicated as we want to, but more times than not, it is important to keep things simple and safe. In the real world, often times the less complex the system, the fewer things will go wrong.

Figure 1: Typical example of a "sandwich-mount" product installed between the pneumatic actuator and valve.

Mechanical Characteristics

Perhaps the primary advantage of the mechanical Partial Stroke Test Device is just that: It's mechanical. A typical installation of a mechanical Partial Stroke Test Device would be to mount the device "sandwich" style between the valve bonnet (mounting flange) and the drive face (or bottom) of a pneumatic valve actuator. ***(See Figure 1)***. Within the device there is a drive mechanism that, once engaged, prevents the de-energized actuator from causing the valve to stroke more than a specified percentage of full travel—thus accomplishing the partial stroke. There is no mandatory device requirement to integrate it into the control loop or add ancillary controls. Therefore, there is no complexity added to what might already be a rather sophisticated control loop or shutdown system.

Field Retrofits/No Calibration

Although Partial Stroke Test Devices are often supplied with a new valve/actuator package, they are also field retrofitable to existing valves. As mentioned previously, typical installation of these products is to sandwich them between the valve and actuator. Mechanical partial stroke devices can be furnished with mounting surfaces premachined to fit an existing valve and actuator interface. This makes the installation of the device simple and cost effective. In fact, depending on the specific valve and actuator, in many instances the sandwich-style device can actually replace typical valve/actuator mounting hardware.

Instrumentation personnel and software programmers are not required to install the devices, nor is commissioning or routine calibration of controls required, because there aren't any. Most process plants have qualified in-house mechanics or Valve Automation Centers nearby and, since there are no additional controls required, installation cost savings can be realized when compared to electrical or controls-driven test systems.

Real World Automation

Although the point behind partial stroke testing is to establish a statistical analysis for lowering the Probability of Failure on Demand, as one industry speaker recently put it: "Calculations are not necessarily reality!" Therefore, the process operators must take care to assure that real world conditions are considered when selecting a methodology for partial stroke testing.

ESD valves are often large and are typically operated by pneumatic or hydraulic piston cylinder actuators, or electric motor operators. Due to the critical nature of the application, one would expect the ESD valve to seldom operate. Although piston cylinder actuators are considered extremely reliable, in the real world these devices are not always smooth-acting. The less often they are stroked *(as in the case of a typical ESD valve application)*, the less smooth is their operation. This might be caused by the elastomeric piston o-rings taking a set against the interior surface of the cylinder.

Most of the non-mechanical Partial Stroke Test Devices assume a relatively smooth movement of the valve actuator and that the SIS will act in a consistent manner, independent of environmental conditions such as temperature and humidity or how long the valve rests between test cycles. This is rarely the case. The primary function of a mechanical Partial Stroke Test Device is to stop valve movement at a specified percentage or degree of valve closure and will not give spurious SIS trips (alarms) based on extraneous conditions.

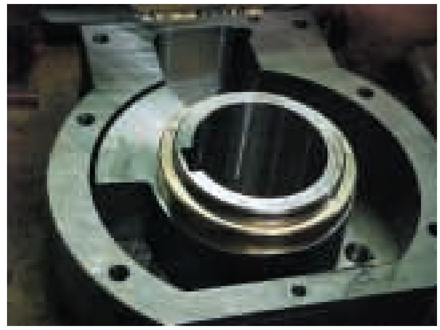

Figure 2: Fabricated body of a Partial Stroke Test Device. Valve Stem would be connected to the device through the bore and keyway.

Figure 3: During normal operation, the device is passive and will allow the valve to ESD on demand.

Figure 4: When a partial stroke test is required, the device is "engaged" and the ESD valve will only travel to the specified percentage of stroke. The device mechanically prevents movement past the interlock.

Further, when using non-mechanical or controls-driven partial stroke test systems there is an assumption that the test device or system will actually prevent the actuator from driving the valve past the set point to the fully closed position. In the real world, the stored energy in an actuator may drive the valve past the set point and actually allow the valve to close, forcing a process shut down. Mechanical devices physically prevent the valve from moving past the specified test point. Once the test device is engaged, the valve cannot move past the set point. ***(Figure 2 - Figure 4)***

Many process plants also use electric Motor Operated Valves (MOVs) in critical process applications. Although most MOVs have internal mechanisms that can be set to stop valve movement at a specified percentage of stroke, plant operators often select a mechanical Partial Stroke Test Device to prevent valve closure should the internal mechanism malfunction.

Man-Machine Interface?

Partial Stroke Testing is receiving increased attention as the aforementioned industrial standards are considered by industry. Progressive refineries, process plants, pipeline companies, etc., are going through an evolutionary process of developing the methodology by which they will comply with the standards and how those methodologies will be implemented. One of the considerations is, to what extent should plant personnel be proactively involved in performing the test of process valve Safety Instrumented Systems?

One philosophy of methodology calls for a Man-Machine interface. In the simplest format, mechanical Partial Stroke Test Devices provide for a plant maintenance person to locally engage the device using a controlled key ***(See Figure 5)***.

By design, the key cannot be removed from the mechanical testing device while it is in the test position. If plant operations personnel know the key is in their control and not in the test device, then they also know the device cannot be engaged. When it is time to test the valve, the maintenance person inserts the controlled key into the device, engages the device and then informs the control room that the valve is now ready to test. When the SIS test is simulated, the person witnesses and reports the event, usually by radio, to the control room, and then resets the system. Plant operations, safety engineers and management are assured the of the system's reliability because "the man saw it function". ***(Figure 6, Figure 7a, and Figure 7b)***

Figure 5: For manual operation, a controlled key is used to engage the Partial Stroke Test Device. The key cannot be removed from the mechanical testing device while it is in the test position. If plant operating personnel know the key is in their control and not in the test device, then they also know the device cannot be accidentally engaged.

Management philosophies at other plants may hold a different view: They want the entire system to be automatic with absolutely no human interface. Many mechanical Partial Stroke Test Devices provide for automatic operation as an option to the Man-Machine interface. Under this methodology, a remotely controlled mechanism is used to engage and disengage the device and there is no key control system. The ESD valve can then be tested either by a signal generated by the control room or any number of other sources without field personnel involvement.

Mechanical Partial Stroke Test Devices offer plant operations and maintenance management both manual or automatic operating options as their philosophies dictate. In either case, diagnostic devices can be integrated into the system to report specific operating details of the SIS function.

Integrated Data Systems

Some end users are beginning to investigate diagnostic technology for valve maintenance considerations. The data acquired from these systems may be helpful in determining the operational status of an automated valve. Even though mechanical Partial Stroke Test Devices do not *require* ancillary controls, such controls *may* be added if the end user specifies them ***(Figure 8)***. For example, if the user would like to have a data acquisition system to determine if the valve/actuator package is experiencing a change in run time trends, the actuator top works can use standard diagnostic technology to report that information. But because the mechanical device is engaged during the test, the end user has assurance that the actuator will not stroke the valve past the set point.

A mechanical sandwich-type Partial Stroke Test Device may also come equipped with its own data point device *(such as limit switches)* for positive annunciation to the control room indicating whether the device is engaged for testing the Safety System. Some may want to use such a device to gather information for the data acquisition system such that auditable reports, testifying to time and date of the test, can be generated (Reference ISA-S84.01, paragraph 9.8.1).

Controls can also be configured to automatically disengage a Partial Stroke Test Device in the unlikely event of an ESD occurring during the test.

True Safety System Tests

As previously stated, a mechanical Partial Stroke Test Device requires no extraneous controls or devices to be added in the safety control loop. When the device is tested, all the actual SIS components, controls and elements used in an ESD or safety valve will be activated. The user has real information about the exact controls that will be relied upon to protect his plant and personnel.

Valverciser™

An additional feature of mechanical Partial Stroke Test Devices is that they are not only applicable to safety related applications, but can also be used to enhance the operation of the valve. In many process applications the chemical composition of the flowing fluid causes material to build-up on the valve internal body and trim surfaces. Over time, this build-up may cause the valve to "stick" in position and not stroke. Partial Stroke Test Devices can be used to simply "exercise" the valve by allowing it to partially stroke, keeping the valve surfaces that are required to move free from material build-up.

Many mechanical Partial Stroke Test Devices can also be configured to accommodate maintenance lock-in, tag-out requirements as well.

All Things Considered...

Now that we have fully explored the benefits of mechanical Partial Stroke Test Devices it should be clear that the simplicity, safety, reliability, and cost advantages of the devices far

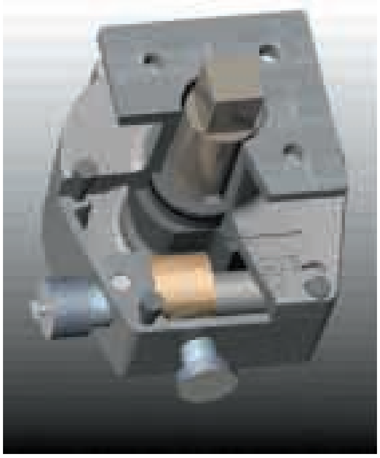

Figure 6: During normal operation, key is kept in a controlled environment and device is free to operate and is transparent to the ESD valve operation.

Figure 8: Although mechanical Partial Stroke Test Devices do not require ancillary controls, they may be added if specified.

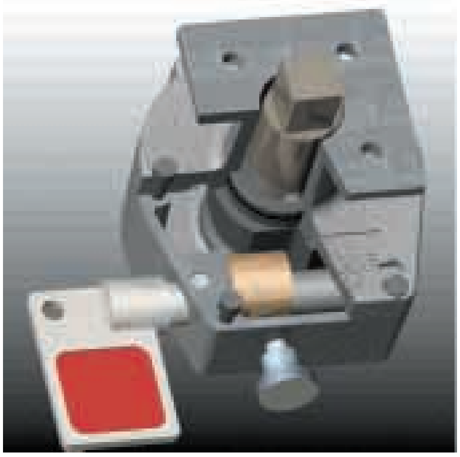

Figure 7a: When it is time to test the ESD, maintenance inserts the controlled key into the device…

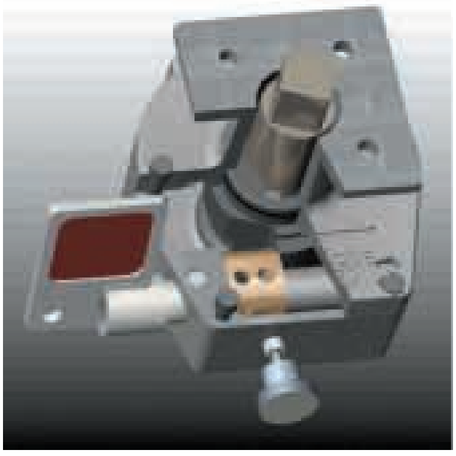

Figure 7b: …the device is then "engaged" and maintenance informs the control room that the ESD is now ready to test.

outweigh the whiz-bang factor of adding more controls and instrumentation to what is probably already a sophisticated valve safety system. Consideration and use of the mechanical devices will lead to "sunny days ahead" when battling the oncoming storm of standards compliance! VM

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Critical Valve Test?
D-STOP™ it!

Plants need to make sure ESD and other critical safety valves function properly now that maintenance shutdowns for "full-stroke testing" are less frequent.

The DynaTorque D-Stop™ (Patent Pending) allows safety control elements to be tested, but does not allow the valve to fully-close during the test so the "revenue flow" is not affected. Partial Stroke Testing may lower the Probability of Failure on Demand (PFD) or may increase the time interval required between full-stroke tests.

The D-Stop™ covers actuator torque ranges from 3000 lb-in to 4,000,000 lb-in. It is a reliable mechanical device. Diagnostics and ancillary controls can be added, but they are not required. No software or commissioning, so capital costs are low.

Most important? The D-Stop™ keeps the system simple and safe. In the real world, the less complex the system, the fewer things can go wrong!

Limit Switches (left and bottom) may be added to provide feedback to I/O system indicating the D-Stop™ has been engaged and that the device is in the *test* position. Data points can be fed to a data acquisition system for the Partial Stroke Test audit trail.

For remote and/or automated applications the key and safety release are not required. The top actuator controls the valve, while the smaller actuator on left engages/disengages the D-Stop™.

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