

¹VALVE RANKING AND PARTIAL STROKE

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KEY WORDS

EMPLOY PARTIAL STROKE TESTING (PST) ADVANCES TO BPCS FINAL CONTROL ELEMENTS TO REDUCE MAINTENANCE COST BY RANKING CRITICALITY AND PERFORMING TRUE CONDITION MONITORING.

INTRODUCTION

This paper describes the CPI mind-set and advocates a new approach aimed at engineers and maintenance managers responsible to shift gear from time based testing to performance based maintenance on all final control elements for BPCS and SIS. It is assumed that they are familiar with the concepts of Safety Instrumented Systems(SIS) and their design. This paper is to present the current practices and developments in the field of regulating control valve and on/off valve testing, in particular automated Partial Stroke Testing (PST) and its applications. An attempt is made to justify Diagnostic Coverage Factor (DCF) as the key to implement on line trouble shooting and repair of all final control elements. A quantitative approach is the better way than statistical techniques as presently practiced.

The author intends to show the advantages of this approach over time-based, reactive repairs to knowledge / performance based maintenance testing to meet OSHA 1910 requirements. Above all it makes business sense to monitor systems and components for performance to maintain integrity levels as designed. The by-product of this thinking is to do value added work by on-line testing and analysis of valve performance under operating conditions.

The automatic data collection while doing PST on a SIS valve offers significant benefits over its manual counterpart. This can be used to supplement a Full Stroke Test (FST) program, reducing the average probability of failure on demand (PFD_{avg}) of the SIS loop. That automatically increases its Safety Integrity Level (SIL). This means an increased Diagnostic Coverage Factor (DCF or Cdt), by utilizing fully automated testing, requiring no manual intervention. Presently SIS systems are disabled or unavailable while performing manually initiated PST, whereas the asset remains protected during the automated Partial stroke testing. To realise these benefits a Diagnostic Coverage Factor, DCF or Cdt for the automatic PST must be established in order to calculate PFD_{avg} of the SIS function. The ARC White paper by the advisory group has shown that for an automatic PST performed, using Neles ValvGuard VG800 equipment, on ball a valve with safety function 'to close on demand' the mean DCF expected would be around 85%. Though design details are not available this is easily achieved with digital positioners and deviation alarms. However to

minimise the risk of spurious alarms from the PST equipment, several vendors recommend to configure the automatic PST to detect only the 'valve fails to move' and 'valve moves but delayed' failure modes with a resulting reduction in mean DCF below 75%. Time to move and Failure to start the travel are the main consideration.

An application taking full advantage of the benefits of the automatic PST is described in this white paper in a BP Refinery Project on 'Manufacturing Vision' employing several SIF at various Safety Integrity Levels.

Historical background

In Chemical process Industry, (CPI) and large Petroleum Refineries it was customary to pull and repair valves during T/A. Subsequently it evolved into performing diagnostics on-line to monitor the condition of the valves before the pull. That involved classifying them based on their availability to pull during the run (Bypass arrangements) or cost of one failure that results in production loss and unplanned repair cost. This classification based on risk and repair history resulted in a small percent of critical valves. This reduction of valve repairs resulted in questioning the original classification basis. The fear factor and emotions were a major component of this decision making process by maintenance, production and reliability engineering prior to T/A. Now CPI has added all SIS valves to this criticality mix for maintenance. The SIS population in any major plant is about 2-5%. Now adding the maintenance requirements of bad actors from SIS, which is mandatory to maintain SIL levels to BPCS we need to find a new way to arrive at problem valves for repair that makes economic sense.

Technology to the rescue

Emerson Process Management and Honeywell and others have come up with on line data collection on Loop performance and signature analysis. They have added the diagnostic data base to loop behavior. This sophisticated technology evaluates the performance and at the same time guide the user to hardware related clues for resolution. Valve maintenance is now tied to measured performance. The only problem is how to do likewise for On-off valves in SIS applications where the valves remain in saturated conditions. There are several ways to collect the data on SIS valves since the BPCS valve performance data is readily available on DCS.

Simply put, DCS collects loop performance data, like transmitter response, controller tuning, valve response etc. for a short time. and the information is sent over phone lines to their systems analysis group who generate a performance signature for all the components in the loop. At different load conditions signatures point the problem as process or tuning or Valve behavior guiding the engineer to likely problem area.

Loops are classified as Best and worst; comparisons are made with a statistical industry average as a benchmark. Depending on the sample volume, performance is verified against assumed or perceived performance. Human factor is removed in understanding performance and in turn open up loop improvement opportunities. Valve responses typically indicate problem areas so the technician can focus and seek on line solution.

When valves are in open or closed position they are saturated and treated as open loop.

Partial Stroke testing to the rescue (PST)

The probability of a valve failing to perform its designed function increases with age and this probability can be treated as a linear function over time. Failure rate increases when test

interval is 10% or less. Testing of SIS valves is required as part of a normal operating procedure or OSHA Mechanical integrity requirements, to reveal any failures in the valve components which may prevent the valve from performing its function, to either fully open or fully close on demand. In some cases they need to meet specific leakage requirements. A successful test of the valve at any particular time will lower the probability that the valve will fail to function correctly on demand by an amount dependent on the diagnostic coverage factor (DCF) of the test. The higher this diagnostic coverage the more of the valve's potential failure mechanisms are tested and the more its probability of failure on demand is reduced. The frequency of such testing also plays an important role in monitoring the valves integrity, as between tests little information is obtained about the valve's condition and we can only make a theoretical prediction as to the likelihood of the valve functioning correctly on demand. It therefore follows that the higher the testing frequency and the higher the diagnostic coverage factor of the test, the more information we know about the valve at any point in operation and the more certain we are of the valves actual ability to function correctly on demand.

Full stroke testing (FST)

Function testing of full stroke by opening and closing valves is common in industry during planned outages. Operators and techs that perform most of the work witness it. The confirmation that the valve has reached the desired position and it reached it in a specified time, is often the only check performed during the test to establish the integrity of the valve's operating mechanism. Leak test is not part of this test and watching the travel validates action and the valve closing matches the signal.

Full stroke test of a valve, performed in the described manner has a high diagnostic coverage factor (90%- 95%) and conveys a trouble free operation and a lot about the valve's operating condition. It confirms that the valve functioned as designed. The only disadvantage is process interruption and labor-intensive manual work. This aversion to taking unnecessary risk in an operating unit results in extending the full stroke test frequency out to coincide with the planned outages and rely more on PFD_{avg} predictions based on the valve's historical performance and repair history.

Manual partial Stroke testing (mPST)

Field mounted panels enable manual stroking by pneumatically or mechanically 'gagging' the valve's displacement stem at the desired partial stroke position, say 10% to 25% before initiating a displacement of the valve in the normal manner. The check thus performed validates the valve plug displacement by the amount allowed by the 'Gag' is normally the only check performed during the test to establish the integrity of the valve's operating mechanism.

The PST causes minor disturbance, but usually recovers fast. The Diagnostic Coverage Factor due to PST on an on-off valve is lower than FST. We cannot eliminate FST altogether. Since a PST does not affect the production it can provide an insight into the performance of the valve between FSTs and can potentially be used to supplement a FST program, allowing the FST frequency to be more confidently extended. The disadvantage of Manually initiated PST is that during the test the valve is not safe, as the gag is preventing the valve from operation, thus exposing the property to dangerous condition. As a result manual testing of PST will cause nuisance trips, inadvertently leaving the gagging mechanism in place will result in failure of the system to protect the asset.

Automatic Partial stroke testing

Control valve vendors have introduced smart positioners and new software for automated PST including Metso Automation's ValvGuard and Emerson's DVC6000 and several others. The new software offers all kinds of data on valve behavior without the drawback of disabling nature of manually initiated PST. The usual technique is to bleed the air supply or pulse the solenoid valve till the desired travel in the specified time is achieved. Thus partial stroke is produced by controlled air signal, travel and timing while collecting several samples of the status of the valve. The data is automatically analyzed and compared against the base line performance when new, with any disparities, which may indicate that the valve may be unable to complete its function to fully open or close. Also the operator gets a failure alarm. This instantaneous analysis gives automatic PST higher DCF. Further more it can be programmed to test at selected intervals without manual intervention. Power loss from the LS will result in fail-safe condition at all times ensuring the availability of the system even during testing times.

Automatic PST and smart positioner can permit a high frequency of partial stroke testing, which will result in higher SIL. Using these numbers in Markov model for Final element indicates a lower PFD_{avg} for the system, resulting in avoidance of unnecessary maintenance of the valve.

When will the Process Industry realize the full potential of Condition monitoring?

So far the industry leaders are promoting the benefit of PST in SIS applications and DCS vendors are singing the benefits of advanced process control, optimization and online loop performance leaving the end users to wonder whether the two will intertwine to benefit the customer in ownership costs. As ISA Standards writers in the US we have to address dissenting votes before realizing its full potential as SIS integrated with BPCS. Industry Champions will have to try and combine the two technologies and the vendors have to come up with DCF numbers similar to Cv data for control valves and on-off valves. Direct benefit will be less components, thus avoiding redundancy in SIS loops, less man-power needs, extension of T/A to 10 years, over all reduction of system PFD_{avg} of the SIS loop and by extension to BPCS. In general control valve sizes may not matter, however spurious trips will become a problem because of increased activity while on line.

Automated PST for SIS applications have opened the eyes of many control engineers to question why not extend this logical approach to BPCS final control element availability, not just by statistical means but by on line analytical approach. This will involve extensive R&D work to combine the technologies by which published DCF will enable future engineers to design systems for BPCS and SIS using a model based approach for system integrity.

Maintenance and upkeep of these operations will be truly condition based reducing the overall cost of ownership and operation. Complying with OSHA regulation will make not only safety sense but also good for business.

Glossary of terms

PST Partial stroke testing

FST Full stroke testing

DCF Diagnostic coverage factor

PFD_{avg} Probability of failure on demand avg.

BPCS Basic process control systems

SIS Safety instrumented systems
T/A Turn around
CPI Chemical process industry
DCS Distributed control systems
LS Logic solver
OSHA Occupation safety and health act

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ARC advisory group, New IEC Standard Force BP to reassess its Valve Testing Procedures

Several technicians who collected performance data in a large Louisiana Refinery to validate the assumptions while implementing IEC 61511.

Neles Metso automation Application report

Honeywell sales application literature.