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Control Valve Performance Monitoring and Diagnostics

Incorporating a smart digital valve controller can help a control valve monitor its performance and health, and notify the operator of any performance degradation. By Dr. Kung Hun Koy and Ivan Poon.

In the process industry, control valve performance is known to significantly influence the performance of the control loop. Poor control valve performance can lead to high process variability

even with a well-designed and tuned loop. A smart control valve can monitor its performance, health, and report to the operator if its performance is compromised. This can be achieved by incorporating a smart digital valve controller. Therefore, the roles of a digital valve controller go beyond the tradition of positioning the valve accurately and in a timely manner. It is a tool for benchmarking the control valve performance 24/7, and an in-house doctor which continuously monitors control valve health and flags the operator if the valve does not perform as expected.

With the microprocessor based FIELDVUE digital valve controller (DVC6200 series), there are abundant diagnostics for determining control valve performance. The Dashboard in ValveLink software (Figure 1) provides a quick overview of the valve performance and any performance degradation (e.g. travel deviation or low of supply pressure) is immediately detected and highlighted.

Performance Diagnostics is the overarching name for a series of valve assembly diagnostic tests that ValveLink software can run while the control valve is online or in-service. Multiple sensors in the digital valve controller monitor the input current from the controller; supply pressure to the device; output pressure to the actuator; valve position; onboard temperature; drive signal; drive current of the internal I/P transducer; and the relay booster position. Using the online data collected above, it can evaluate supply pressure, determine the relay position of the double-acting actuator to ensure both ports of the relay are in the right position, determine the reasons why a valve assembly is deviating from the set point, evaluate the pneumatic paths (I/P and Relay components) for choke, and detect possible leaks in the pneumatic path through actuator diaphragm or piston O-ring. If any fault is detected by diagnostics, a description of the fault is given that includes possible cause/s and recommended corrective action/s as two of the examples shown in Figure 2 and 3.

Another online diagnostics is the continuous friction and dead-band monitoring. Knowing the control valve friction while the valve is in operation can help pin-point control valve performance issue. For example, a power company having a problem with one of its auxiliary steam pressure loops due to high process variability (± 3.5 bar) and an unstable loop. The source of the

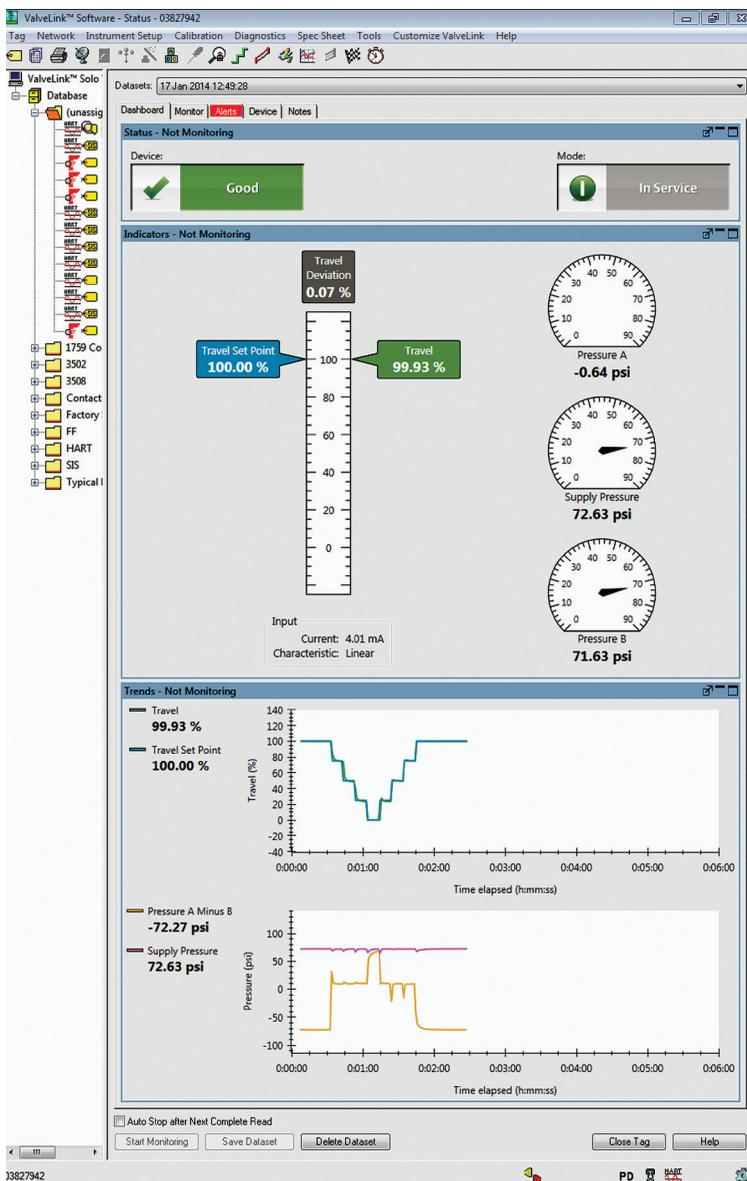


Figure 1. Overview of valve performance with ValveLink software.

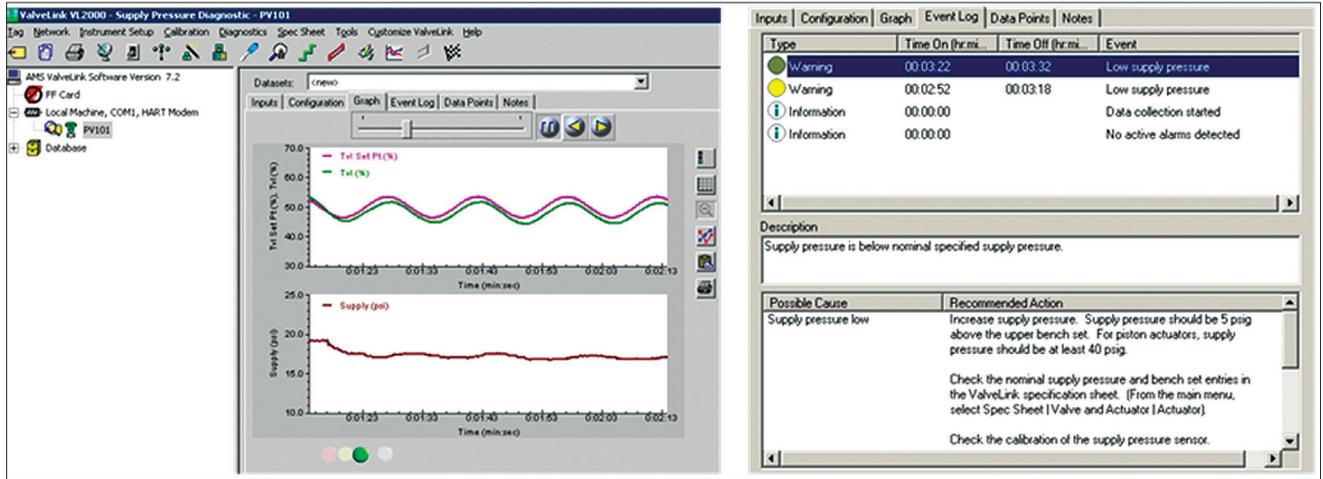


Figure 2. Online supply pressure diagnostics – when low pressure is detected, ValveLink provides the cause of the alert and the recommendations.

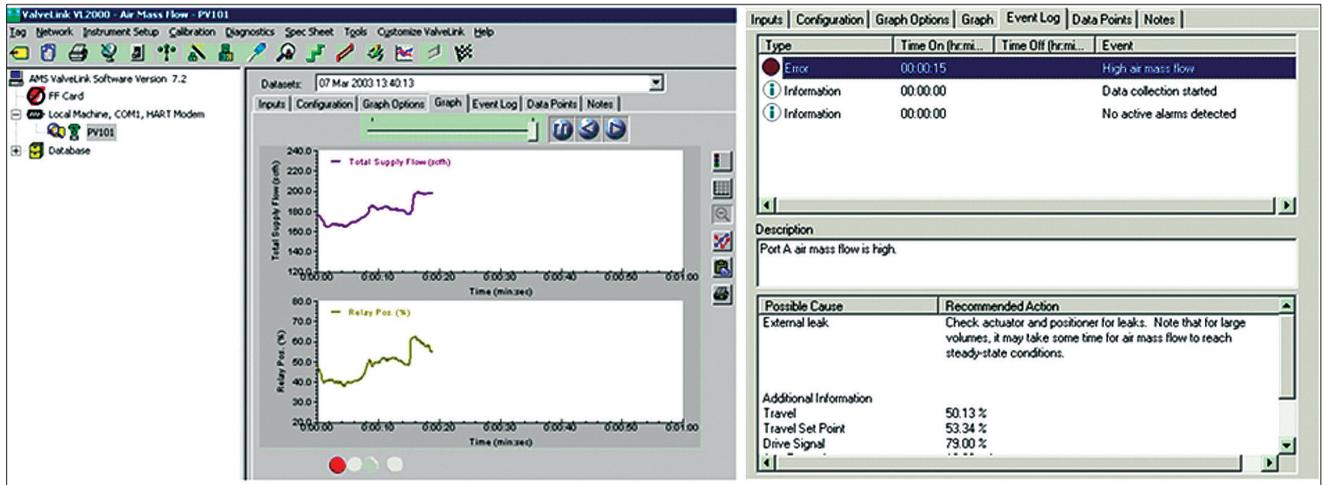


Figure 3. Online air mass flow diagnostics – provide an indication of air leakage when there is external pneumatic leakage.



Figure 4. Auxiliary steam control valve with DVC6000 remote mount.

problem traced back to the control valve for that loop. As part of the improvement, the existing positioner was replaced with a Fisher digital valve controller, DVC6000 remote mount (Figure 4). The remote mount positioner was selected in order to prolong the life of the digital valve controller because of the high temperature environment.

After the replacement and the control valve response were optimized to process needs, there was significant reduction of process variability.

Two months into the operation, the operator observed that process variability is still maintaining well when the valve is operating above 19%. However, it is approximately 10 times more when the valve is operating below 19%. The valve will start to slightly oscillate at this low travel range. Online friction testing at various travels was carried out and the result is shown in Figure 5. The graph shows that the friction value is about 10 times higher than normal when the valve openings are between 16 – 19%. With both the offline test and online test put together, we confirm that the packing friction was not the issue. Thus we are able to narrow down to internal parts such as the plug and cage. The valve was scheduled for repair and during the overhaul it was found that four stacks of the noise attenuation trim were badly damaged and choked up (Figure 6). The damaged stacks corresponding to the travel range cause high friction as the valve traverses through these ranges. The valve performance returned to normal after the trim was replaced.

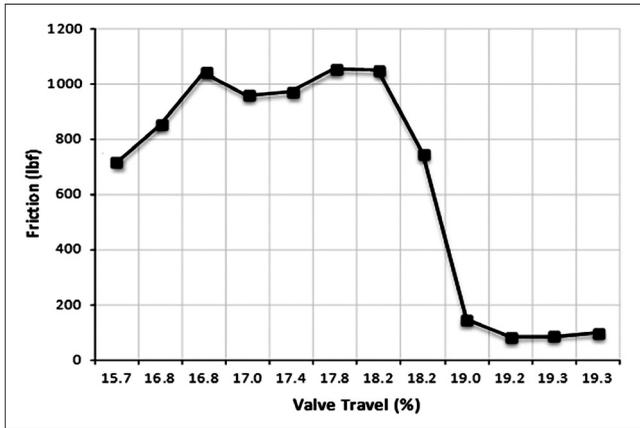


Figure 5. Online friction trend.



Figure 6. Damaged trim.

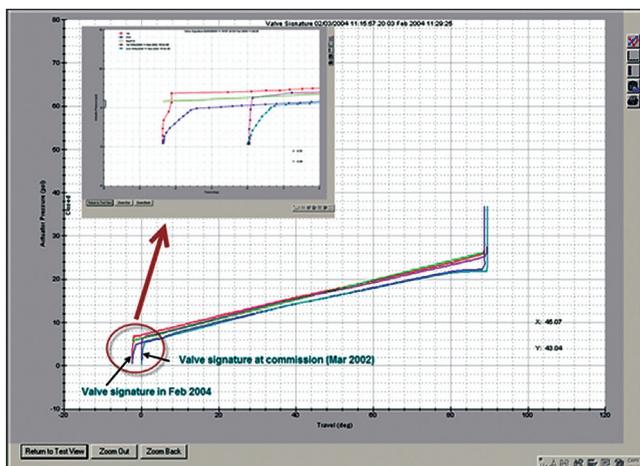


Figure 7. Superimposed valve signature graph at commission and two years after in service.

So far, the online diagnostics are part of the condition monitoring. While the process is running, the digital valve controller is continuously monitoring the control valve performance. When any abnormal condition is detected, the problem is reported to the operator or maintenance personnel.



Figure 8. Damaged HD metal ball seal.

Valve signature

There is a suite of diagnostics that is used for predictive maintenance as well as gauging control valve dynamic performance. They are normally performing when the process is not running (offline) and valve signature is the primary one used to determine the valve and actuator mechanical condition. Issues such as worn seat, worn/bent stem, insufficient air supply, incorrect bench set, insufficient frictional forces, and stuck valve are examples of the issues that can be detected using these tests.

For example, a chemical plant in Asia will have its valves scanned during shutdown as a routine check even though there is no complaint on their performance during operation. From the valve signature taken, it was found that one of the valves was over-traveling based on the valve signature graph. To ascertain the result, this valve signature was overlaid with the signature that was taken during commission two years ago when the valve was brand new. Figure 7 shows the result of the overlay signatures and the insert is the zoom-in of the seating profiles.

In general the valve signature graphs are almost identical except at the seat end where the latest signature graph shows the valve was over-travelled by approximately 2.4 degrees further than the original signature. In many cases, this is an indication of seat/plug damage. Although the valve performance was not compromised, it was recommended to be scheduled for servicing as the valve might be passing, which could affect the process as well as the plant safety. When the valve was serviced, it was found that the seal protector ring and the HD metal ball seal were damaged (Figure 8), which caused the ball to move further into seating than intended. The seal protector ring and HD metal ball seal were replaced before the valve returned to service.

Detailed analysis of the valve signature graph illustrated in this next example is for a 2" fail closed sliding stem valve, 2.5" travel and a volume booster. Figures 9a and 9b are the respective valve signature graph and its analysis at commissioning. The graph shows a slightly aggressive performance on the return stroke, which is due

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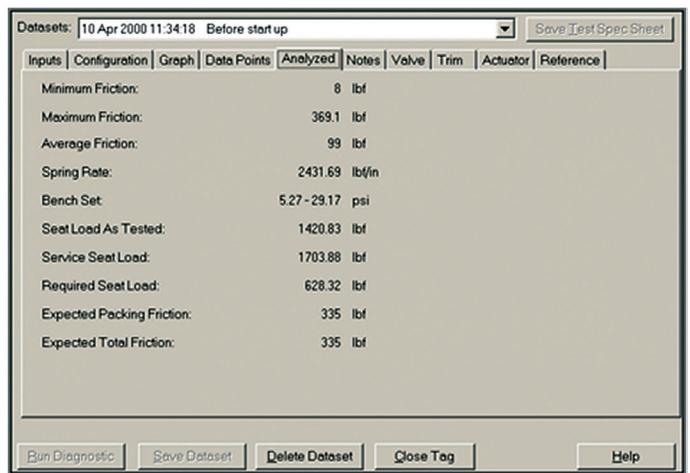
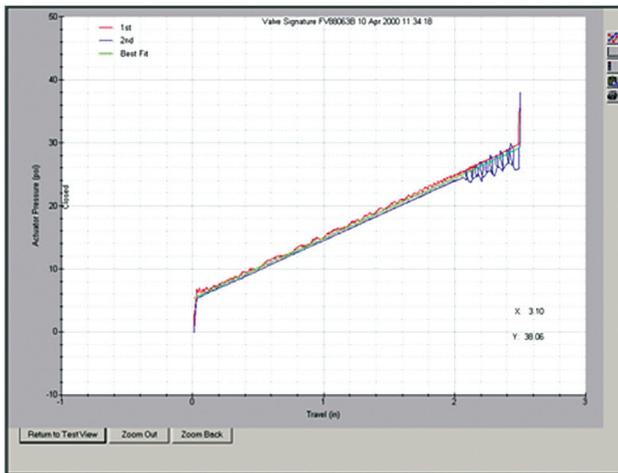


Figure 9. (a) Valve signature graph.

(b) Analysis of valve signature at commissioning.

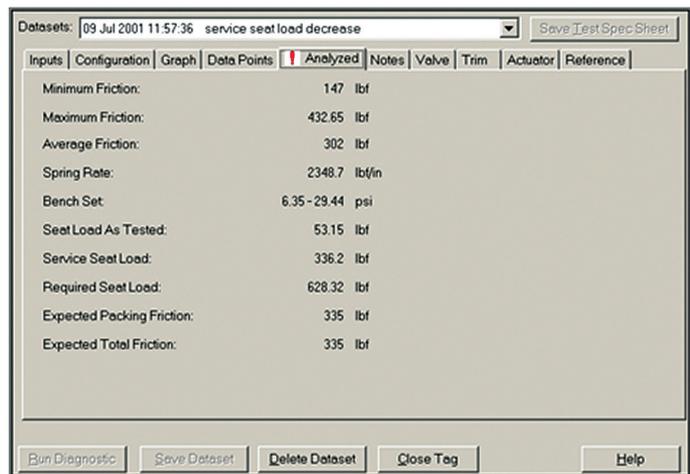
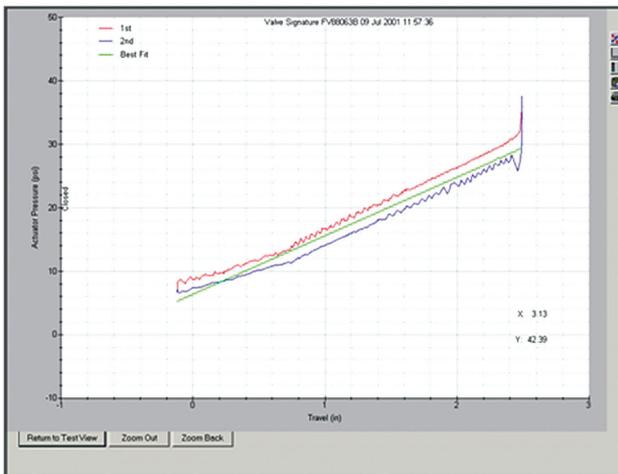


Figure 10. Valve signature and analysis, taken one year after commissioning.

to the volume booster. The fluctuation of minimum and maximum frictions is caused by the loopy opening end. The service seat load is well above the required seat load, hence there is sufficient seat load during operation to fully shut the valve according to their ANSI leak class.

A year after the valve was in operation, there was a complaint of valve passing. A service engineer went on site and ran a valve signature. The valve signature graph and analysis are shown in Figure 10. There are a few observations from the recent valve signature graph.

First, the friction values between 0 – 30% appear to be lower than 30 – 100% of the valve travel range. After the inspection, it was found that the upper part of the stem was severely rusted, because the valve was only operating at up to 30% only. Accordingly, the rusted part of the stem caused an increase in friction.

The second observation was that there was no spike at the seat end, as reflected in the valve signature analysis where the service seat load dropped to almost half the required level. Therefore, the valve was not expected to achieve its shutoff class during normal operation.

The third observation was of the valve over traveling about 0.13” at the seated end. Again, this is an indication of erosion to the seat/plug as in the previous example. Later, the valve was serviced and found that the seat was damaged - the main cause of the seat load reduction.

Online monitoring is a great tool for condition monitoring of the control valve performance while the valve is still in service. It is capable of tracking supply pressure, checking pneumatic leakage, actuator or O-ring leak, friction and dead band monitoring, relay adjustment, pneumatic block, and calibration shift, among others. This condition monitoring is a precursor to the predictive maintenance where the valve is taken offline and detail analysis with Valve Signature can be conducted.

Valve signature provides a quick and effective way of examining inside the valve without disassembling it. The above examples have clearly demonstrated the efficiency of valve signature in determining potential problems with the valve assembly that could affect the control valve performances, and more importantly, plant safety.

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Ivan Poon is a Senior Marketing Manager with Emerson Process Management Asia Pacific Pte Ltd, Fisher Business Unit. He has had 15 years of on-site experience in instrumentation and control valves, and is actively involved in providing counsel and recommendations on critical valve performance. He has also co-authored with Dr. Koy on control valve articles for regional magazines and has delivered many presentations to several professional engineering bodies and tertiary institutions.