



SMART Diagnostics for Preventive/ Predictive Maintenance in the Power Industry

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Agenda

- Current Industry Challenges
- History of Valve Diagnostics
- Smart Valve Positioner Diagnostics
- Comparing Smart Positioner Diagnostic Methods
- Customer Needs and Future Advancements



Current Industry Challenges

Current Challenges

- In order to be successful in today's world, plants must:
 - Produce more with a smaller and sometimes less experienced workforce
 - Extend shutdown intervals and decrease shutdown periods
 - Increased safety and environmental compliance is a constant growing concern
- This requires increased availability of valves and instrumentation...
- There are numerous process measurements related to temperature, pressure and flow... but they are not always directly linked to the performance, status and condition of the valve assembly.



Types of Device Maintenance

- One of two maintenance methodologies have typically been used by plants
 - Reactive Maintenance
 - Preventive (Scheduled) Maintenance
- Reactive maintenance
 - Maintenance after an unexpected failure has already occurred.
 - Unplanned shutdowns can cost 10x more than a planned shutdown.
- Preventive / Proactive maintenance
 - Maintenance is performed at a specific interval (scheduled), whether needed or not (Unnecessary maintenance)
- Predictive maintenance
 - Proactive maintenance action triggered by condition monitoring e.g. device built-in diagnostic (leading indicators) alerts.
 - Only performed when warranted

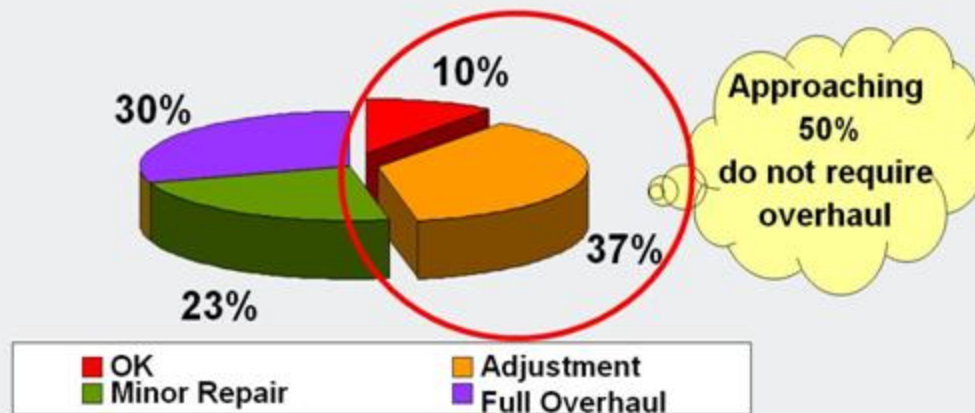


Current Challenges

Predictive Maintenance

- Predictive Maintenance allows you to focus maintenance actions on the valves really needing maintenance. This allows for:
 - Reduced spare part purchases
 - Improved efficiency of maintenance resource allocation
 - Improved efficiency of maintenance planning
 - Increased process availability

Typical condition of overhauled valves during shutdown



Up to 50% of maintenance is unnecessary & 10% is actually harmful – Gartner Group

Real Life Example

2009 Shutdown planning for critical pulp line control valves

Over **80% reduction** in maintenance cost (~\$200,000 savings)

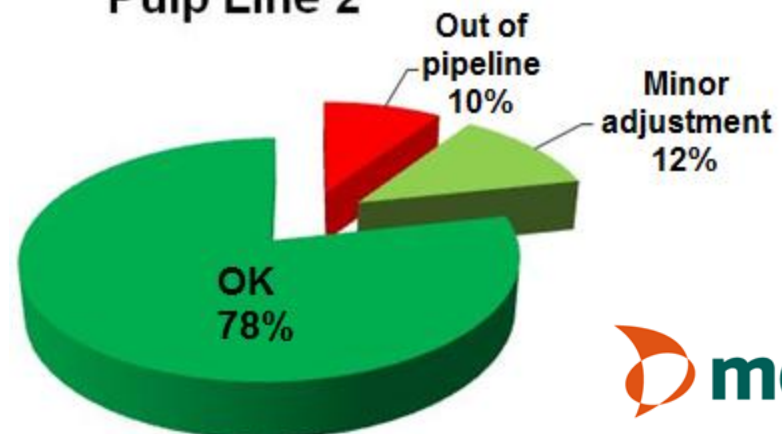
- **Pulp Line 1**
 - 80 critical control valves, no Smart devices
- **Pulp Line 2**
 - 74 critical control valves w/ Smart devices
 - Valve diagnostic analysis performed as a basis of maintenance planning



Pulp Line 1



Pulp Line 2





History of Valve Diagnostics

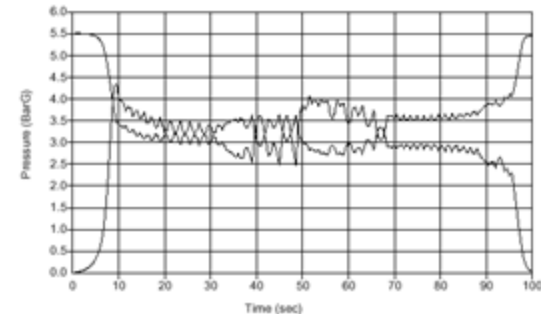
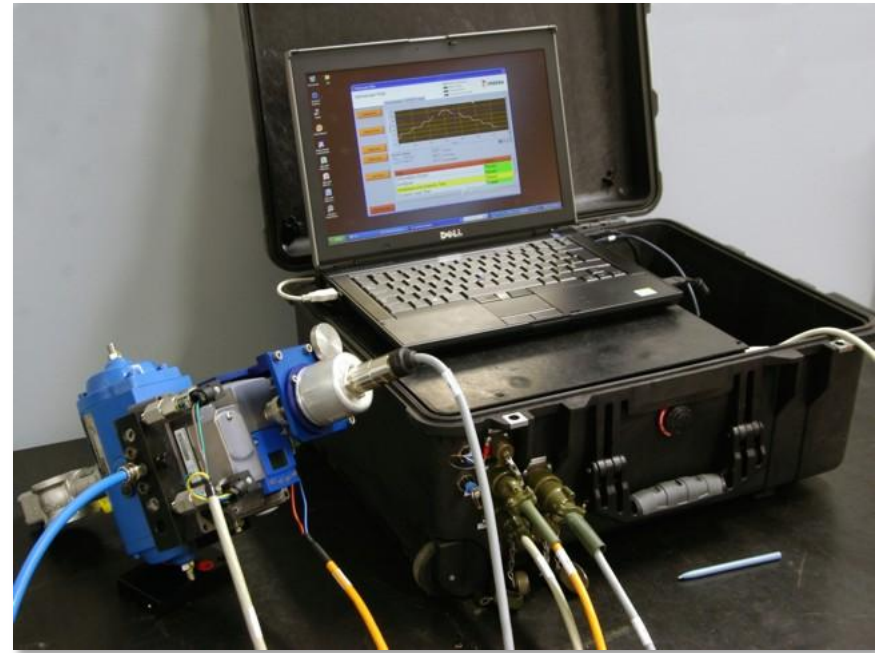
Valve Testing History

- Valve Diagnostics started with expert technicians who would evaluate the valve condition through feel and experience.
- In the 80's, external systems were developed to allow for accurate data collection by controlling the setpoint and monitoring the valve position and pressures.
- Industry standards, such as ISA S75.13 and Entech/ISA S75.25, emerged to define procedures for testing and analyzing valves with positioners.



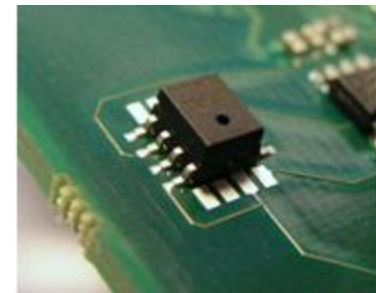
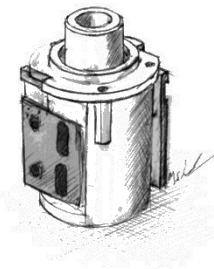
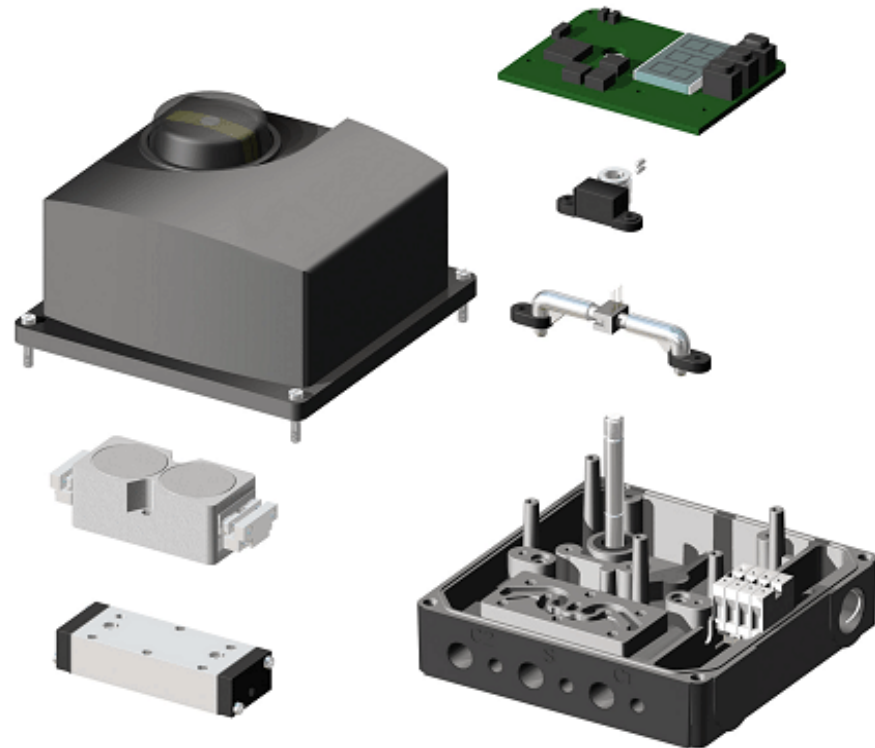
Valve Testing History

- Today these systems are still effectively used to validate the health of brand new valve assemblies as well as verifying the valves condition after a repair.
- They are also used to diagnose the health of the many control valves still equipped with analog positioners.
- This is time consuming, labor intensive, and requires valves to be removed from the process.



Digital Valve Positioners

- Digital valve positioners began coming to market in the 1990's.
- Now sensors could be embedded into the positioner to accurately measure the valve position as well as the pressures in the actuator chamber.
- Microprocessors in the positioner:
 - Simplified calibration
 - Improved valve response
 - Self diagnostics on the positioner
 - Allowed for embedded test routines which mimicked the functionality of the external systems.



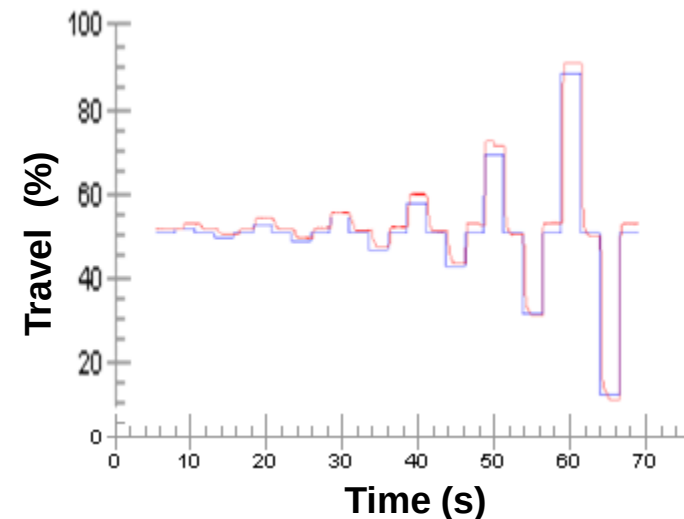
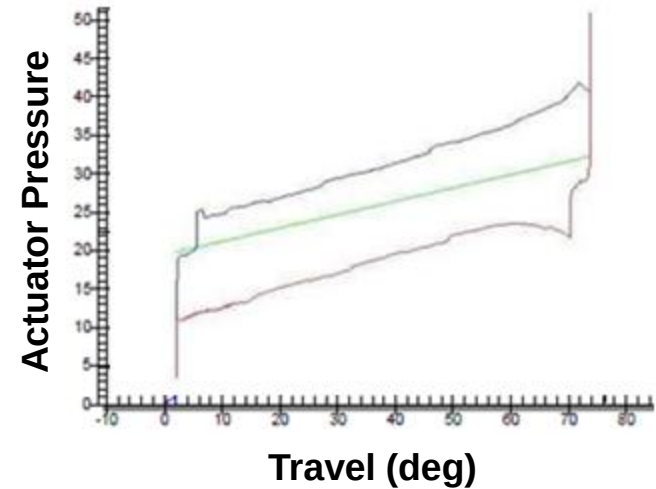


Smart Valve Positioner Diagnostics

Smart Positioners

Offline Valve Signatures

- The Offline tests (such as the valve signature) that were previously conducted using external devices, were naturally embedded into digital valve controllers to eliminate the need for these external systems.
- Many manufacturers provide these diagnostics but the tests and their results are vendor dependent and typically require specialized expertise to interpret.
- Additionally, results must be available from when the valve is new to use for comparison.



Smart Positioners

Offline Valve Signature



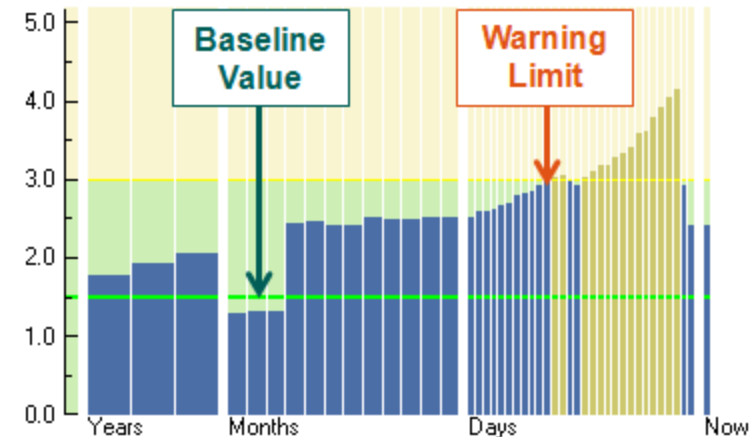
- The main limitation is that these tests can only be run when the process is inactive, and this of course means the diagnostic information is never quite up to date and thus it is not possible to make maintenance/operator personnel aware of the control valves' current condition.
- These obviously do not fulfill the needs of continuous condition monitoring for predictive maintenance planning, nor can they help if troubleshooting is needed while the process is running.

Smart Positioners

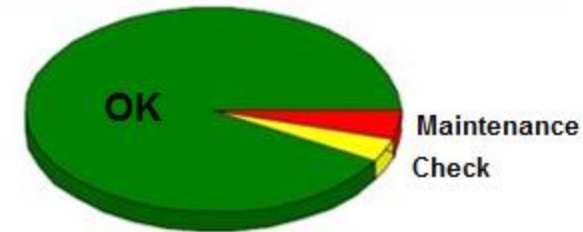
Online Valve Diagnostics

- The second generation of valve diagnostics included run time data for the valve assembly. State of the art valve controllers enabled sufficient run time diagnostics data to support a predictive maintenance strategy.
- This data included, up to 20, runtime measurements of factors such as valve assembly friction and deviations.
- Trending of historical data over the life time of the valve assembly is helpful for determining how possible problems have developed, and how they may develop into the future.

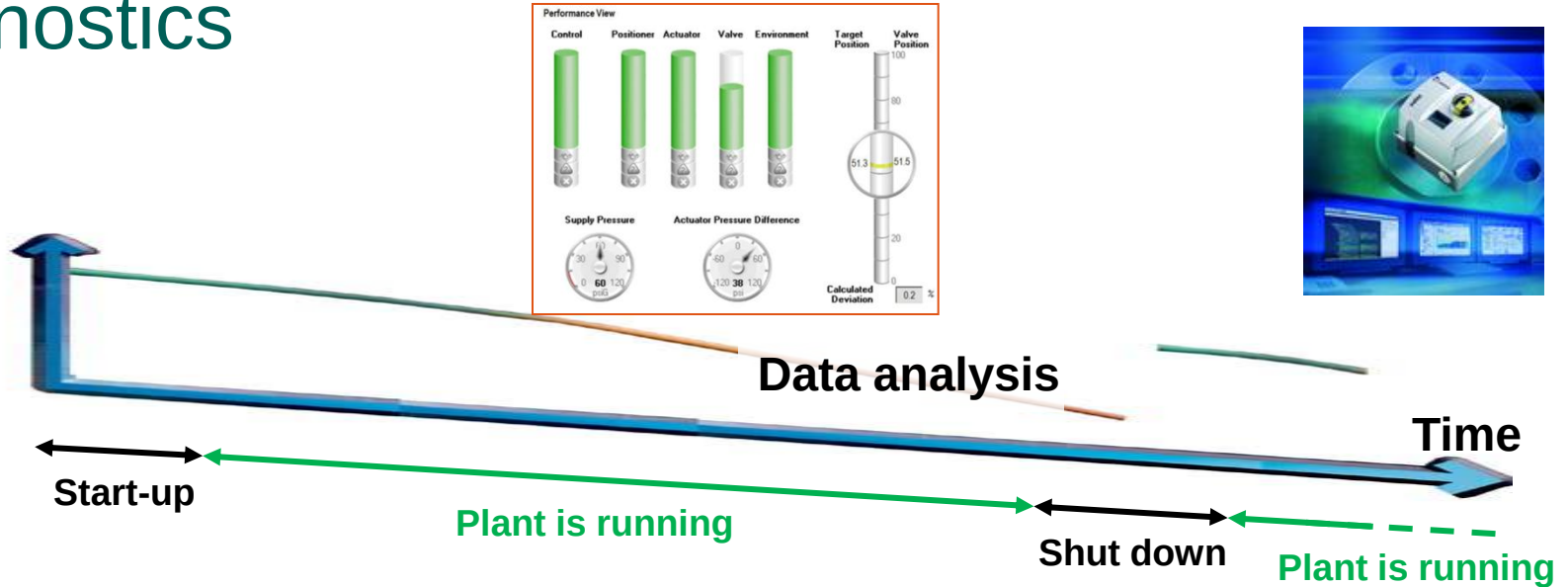
Steady State Deviation %



**In next shut down focus on
23 valves out of 495**



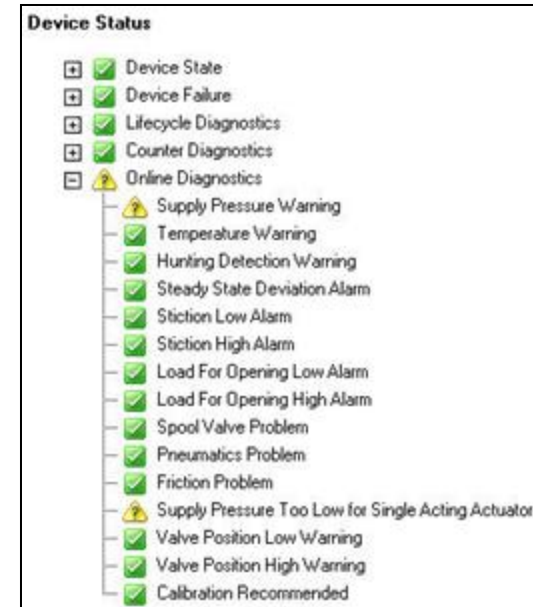
The move from Offline Signatures to Online Diagnostics



- No extra work during start-up or shut down
- Know your valve condition in the past, present and in the future. Correct focus for the shut down maintenance
 - Valve performance is assessed during the run-time
 - Smart devices measure and store the diagnostic data by itself
 - Best possible resolution and accuracy of information

Online Alarms

- Online diagnostics have made it possible for the valve controllers to send alarms to operators.
- These alarms can be triggered by various function related issues, self diagnostics of the positioners, or by alerts based on the actual valve assembly diagnostics.
- As the alarms explicitly indicate that something is already wrong, these warnings give operators a time window to perform remedial actions before the process is affected.
- In each of these cases, only 'yes or no' type of information regarding a set limit is provided, with no information on how this status has been reached or what might happen in the near future.



Online Alarms

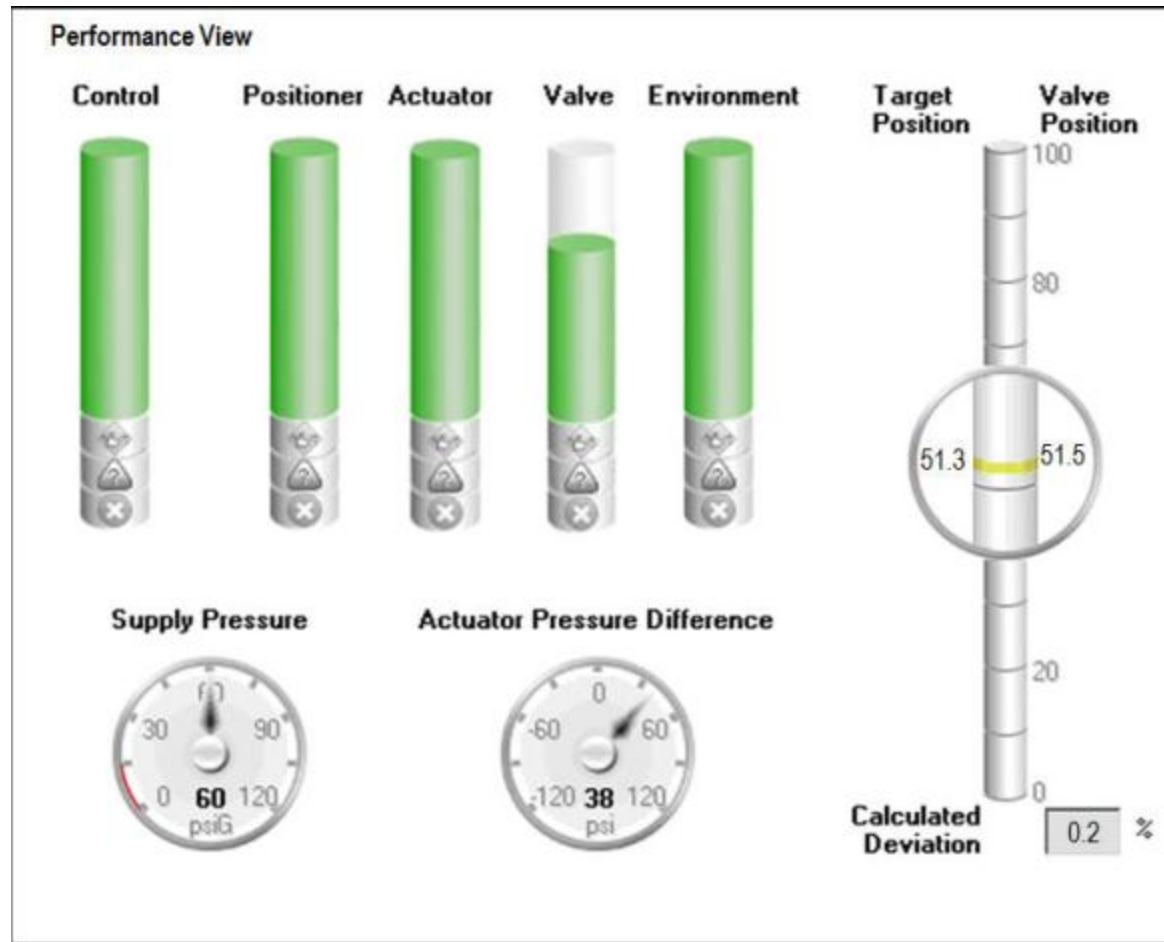
- With large numbers of alarms coming from various manufacturers it is easy for end users to become overwhelmed with “unnecessary” or “nuisance” alarms.
- This has caused confusion and many users to ignore valid alarms.
- In order to standardize alarm classification, NAMUR created the NE107 recommendations.
- Many manufacturers are now following these recommendations to classify their alarms.
- FF 912 Specification implemented NE107 into Foundation Fieldbus

Status Signals	Symbol
Normal; valid output signal	
Maintenance Required; still valid output signal	
Out of Specification; signal out of the specified	
Function Check; temporary non-valid output	
Failure; non-valid output signal	

Simplifying Diagnostics Analysis

- Leading valve controller manufacturers have recently focused on ways to help operators quickly determine the status of valve assemblies with a clear summary of the valve assembly's status, regardless of whether they have in depth training in valve diagnostics. This is referred to as the 3rd generation of diagnostics.
- Graphical displays are used to simplify the users experience and give them all of the key information they need on a single page
 - A summary of the health of the valve assembly components, i.e. valve, actuator and positioner, as well as control performance and the environment.
 - Key measurement values such as the supply and actuator pressure difference is displayed, as well as the target versus valve position

Advanced Diagnostics Made Easy



- Advanced diagnostics help to make correct decisions fast
- Unique and easy segmentation of control valve condition
- Statuses according to Namur NE107

Making the Right Decisions

- Accurate data by itself is not enough; a correct interpretation is required as well. Effectively and properly combining all available information is not always easy. It is possible that some data might be omitted, or that the magnitude of some numerical value might be misunderstood. In today's world, the key point is often to locate and select the right data from the multitudes available, rather than simply compiling more and more information.
- Operators can be most effectively supported by combining valve diagnostics data according to the experience of the manufacturer, before aligning it with the most likely field conditions of the specific use case. The operator can also take into account any process specific experience by refining the tolerable limit values.

Making the Right Decisions

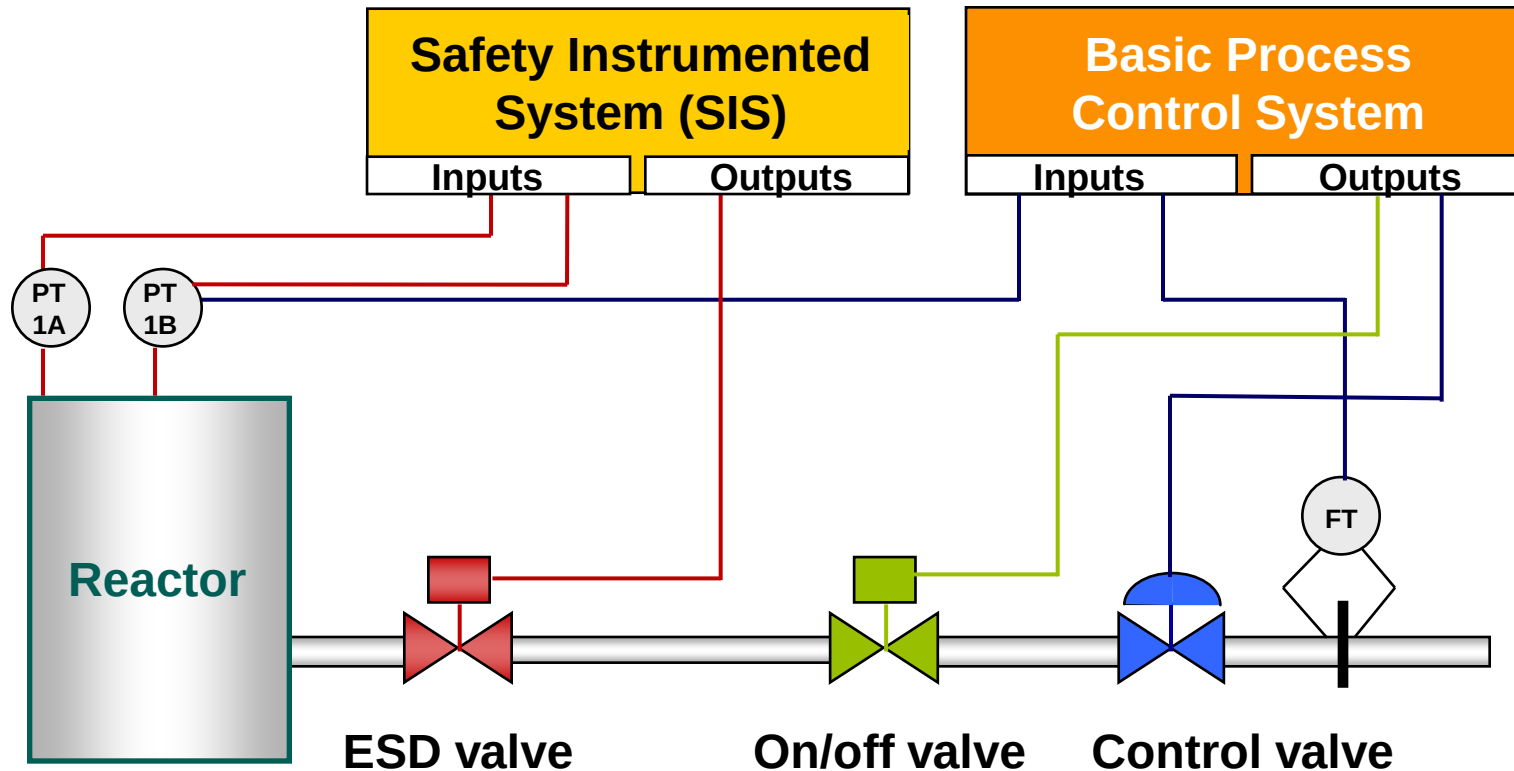
- Through this process, the most essential information can be presented to operators in an effective and reliable way. The training needed to analyze basic control valve assemblies becomes minimal and the experts can concentrate on the key tags that truly require their attention.
- In practice, the majority of control valves normally perform as expected and a check of the indexes and suggested actions is enough. The result of this enhanced clarity is that when more correct maintenance decisions are routinely made, significant cost savings can be achieved.

Description of Diagnostic

Control	The valve is changing direction too often when compared to the amount of valve travel. Check the process control loop. Use the online monitoring to verify that the valve follows setpoint changes smoothly and without delays. Change the performance level parameter from the Position Control menu to stable. If there is instrumentation like a booster or quick exhaust valve, check that those are adjusted correctly and operate normally.
Positioner	Maintenance required Calibration Recommended: A previous calibration did not end successfully, the reason for the calibration failure can be found in the event log. A previous calibration was cancelled. An Assembly Related parameter was changed. The control accuracy may be decreased. Run the auto or manual calibration.
Actuator	Excellent performance. No action.
Valve	Excellent performance. No action.

Recommended Actions

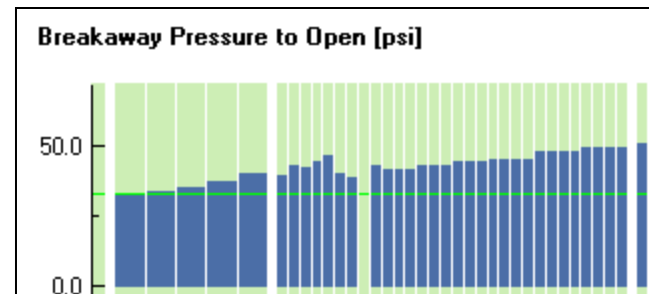
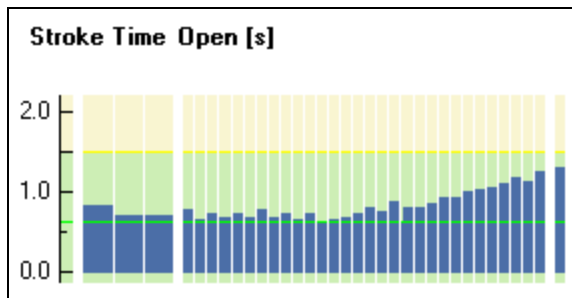
More Than Just Control Valves



- To improve safety and availability, diagnostics are now becoming common not only for control valves but also for:
 - High cycle / process critical on/off valves
 - Safety (ESD) valves

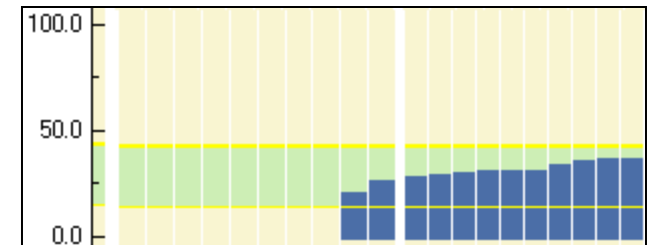
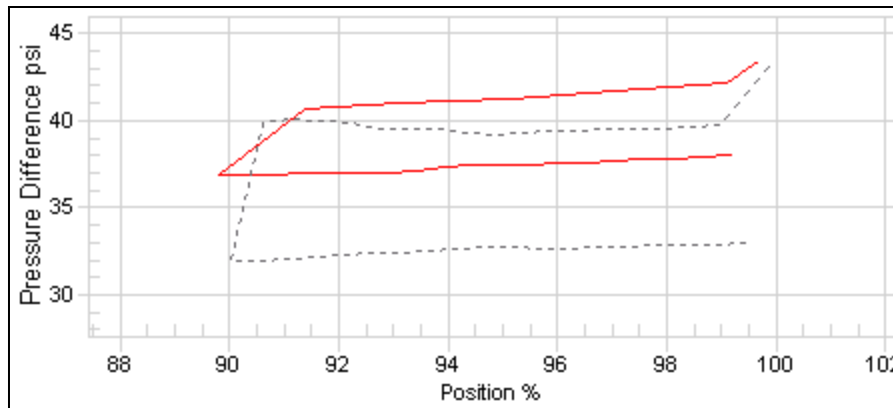
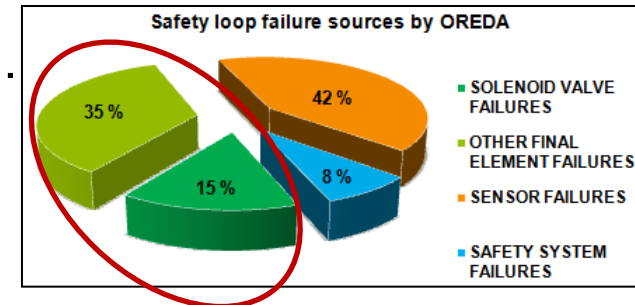
Intelligent On/Off Valves

- When On/Off valves are controlled by solenoids there exists...
 - No possibility for online monitoring
 - No diagnostics on the valve condition
 - Risk for water hammering
- Many **automated on/off valves** are just as critical to the process as control valves. It is now possible to add intelligence to solenoid valves which allows for:
 - Accurate stroke control (speed and profile) to meet the exact needs of your process and prevent issues such as water hammer.
 - Online Diagnostics specifically designed for on/off valves.



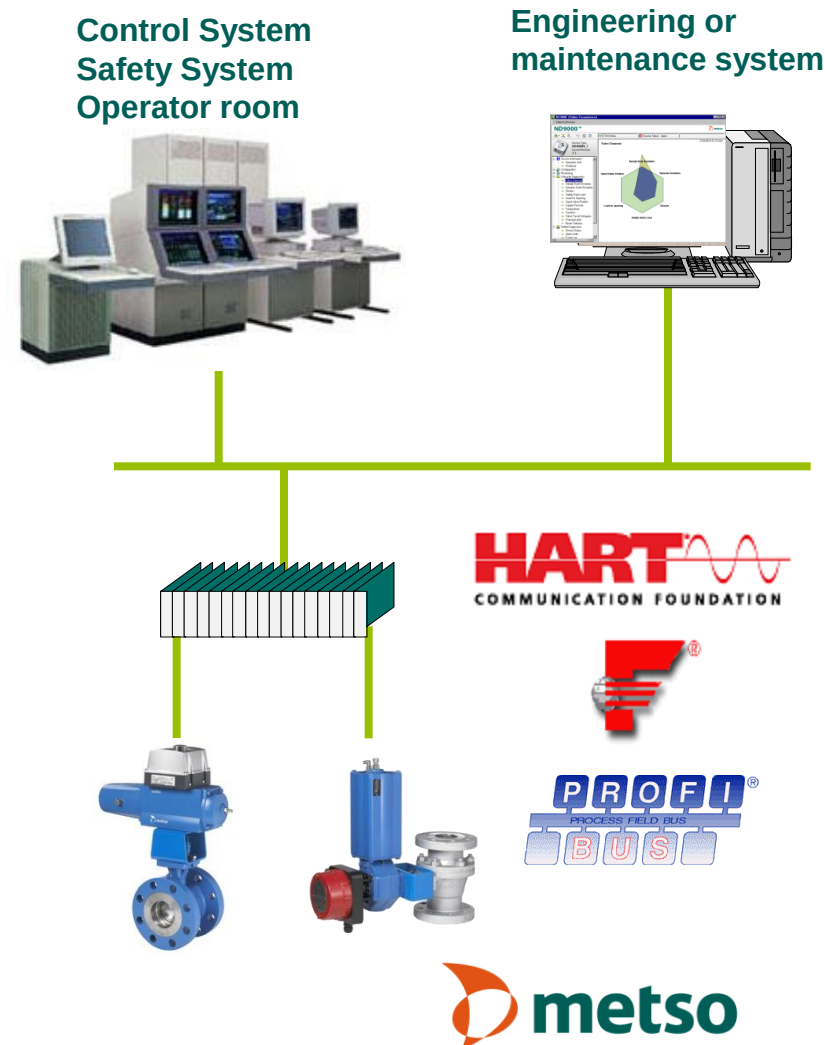
Intelligent Safety Valves

- When Safety Valves are controlled by solenoids...
 - No accurate and safe way to test the solenoid
 - No possibility for online monitoring
 - No diagnostics on the valve condition
- **Safety valves** perform diagnostics through Partial Stroke (PST) and Full Stroke (FST) testing. Smart safety valve controllers can now determine the health of these critical valves while performing these tests.
- In addition to verifying that the valve reaches its stroke position, intelligent safety valve controllers can monitor the breakaway pressures to determine if the friction in the valve is increasing.



Access to Smart Diagnostics

- Accessing all of these diagnostics has been improved through standardized communication protocols and open Asset Management standards.
- Common Communication Protocols:
 - Wired: HART, Foundation Fieldbus, Profibus
 - Wireless: WirelessHART, ISA100
- Asset management:
 - FDT/DTM - IEC 62453 (2009)
 - EDDL - IEC 61804-3 (2006)
 - FDI – Pending approval
- Advantages of FDT + EDDL ...





Comparing Smart Positioner Diagnostic Methods

External systems vs. Smart Positioners

- Advantages of External Testing System

- Manufacturer independent:
 - Don't trust a positioner testing itself
 - Same tests/results for all positioner brands
- Not all positioners can detect:
 - Incorrect positioner configuration/setup
 - Air leaks
 - Backlash in the feedback assembly
 - Positioner malfunction

- Disadvantages of External Testing Systems

- Time consuming and labor intensive
- Valves must be out of service, no online diagnostics while the process is running



Smart Positioners Diagnostic Types

- Smart Positioners have varying capabilities:
 - Smart Positioners with Embedded vs. system based analysis
 - With Embedded diagnostics the positioner stores all of the key information into its own memory so the asset management system simply needs to display it.
 - System based diagnostics require a full asset management system which polls the devices for data and the system performs analysis on the data.
 - Smart positioners without pressure sensors
 - Deviation and time based diagnostics
 - No pressure knowledge so changes in valve friction cannot be accurately measured.
 - Smart Positioners with pressure sensors
 - Deviation, time based, and pressure (friction) based diagnostics.

Example of how Diagnostics are used...

Actuator Diaphragm Leak



Actuator membrane has failed, leakage increasing!



- **Problem**

- Diaphragm Leak is developing in the actuator while the process is running.
- Positioner compensates for the small leak by sending more air to the actuator.

- **Control System Diagnostics**

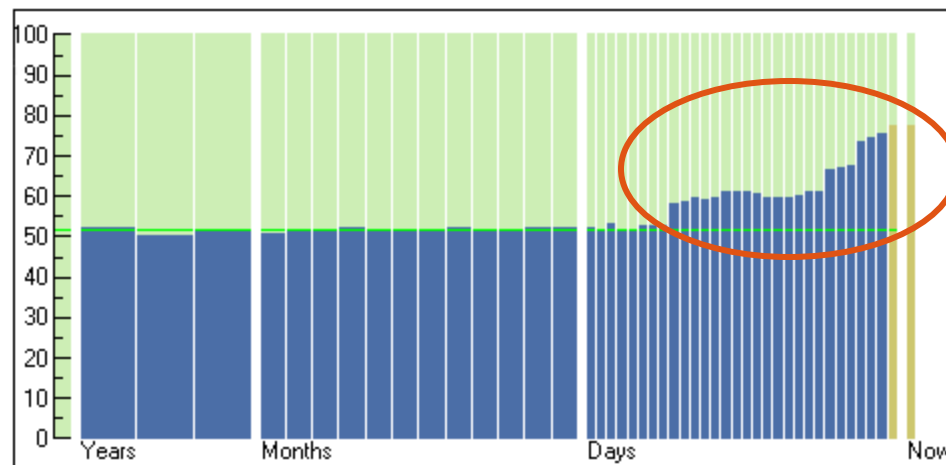
- Once the actuator leak becomes more than the positioner can compensate for the process will be affected and process alarms will be activated

Example of how Diagnostics are used...

Actuator Diaphragm Leak

- Different smart positioner diagnostic levels:
 - 1st Generation Offline Testing
 - Once actuator leak becomes more than the positioner can compensate for a deviation alarm will be activated since it can no longer follow the set point.
 - 2nd Generation Online Diagnostics
 - Trending clearly shows the change in pneumatics output to compensate for the leak. Some knowledge is required to know what this diagnostic means and what actions need to be taken.

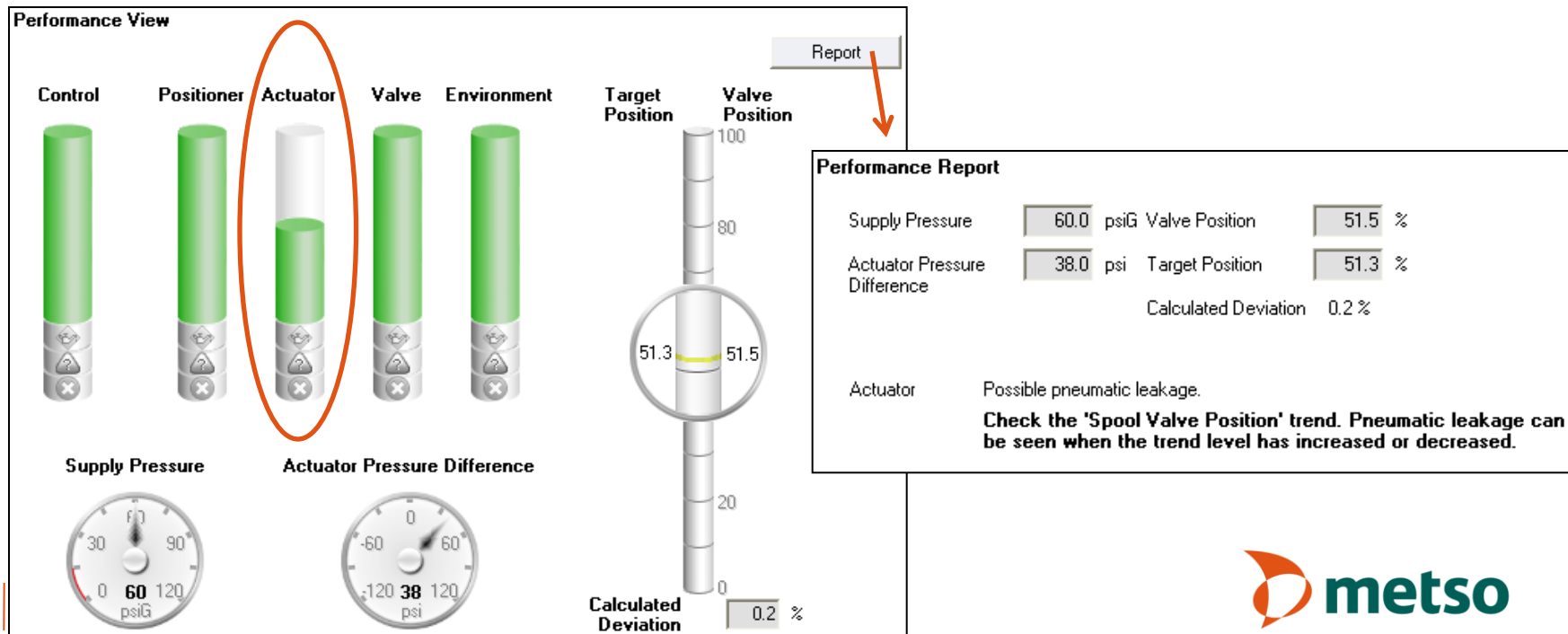
Spool Valve Position [%]



Example of how Diagnostics are used...

Actuator Diaphragm Leak

- Different smart positioner diagnostic levels continued:
 - 3rd Generation Simplified Online Diagnostics
 - Diagnostics are broken down into key indexes and clearly show a problem developing with the actuator. A clear description is given describing the problem and recommended actions.





Customer Needs and Future Advancements

What customers still want from diagnostics...

- When do I need to shutdown?
 - With all predictive diagnostics the question ultimately becomes do I really need a shutdown or can I make it another 6 months until my next shutdown?
 - With safety valves the question is even more critical...
- How do you set the alarm limits for accurate predictive maintenance in my application without creating nuisance alarms?
 - Too loose alarm limits prevent alarms from occurring before the process is affected
 - Too tight alarm limits cause nuisance alarms.
- Where exactly is the problem?
 - Diagnostic results to pinpoint the exact cause of the problem
 - Many diagnostics are inferred because direct measurements are not currently available. For example when looking at actuator pressure changes it is not possible to accurately determine where the friction is coming from.

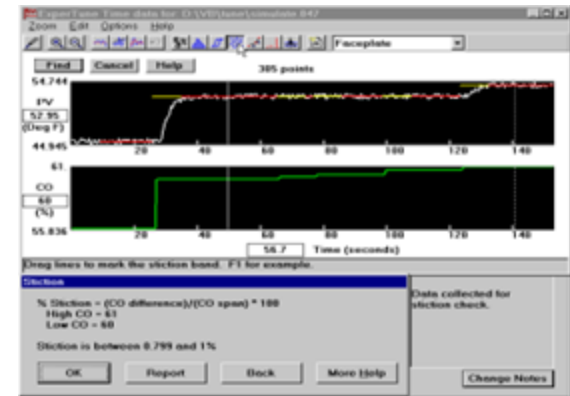
Future Advancements

Low Power Sensors

- Energy Harvesting (Photovoltaic, Thermoelectric, Electromagnetic, Vibration, Acoustic...) coupled with low power wireless technologies (UWB, ANT...) and even wireless energy transfer technologies will increase the availability of measurement data by allowing sensors to be integrated where previously impossible or too expensive.
 - For example:
 - Leakage sensors
 - Emissions sensors
 - Direct torque measurement
 - Communication between loop components (i.e. sensors, valve controllers, external instrumentation)
- The Valve controller can be used as a field server for bringing this additional data back to the user.

Future Advancements

- Integration of process and valve diagnostics
 - Today's Loop Optimization software can quickly analyze our process loops and help determine where problems exist. The software can determine basic valve problems such as incorrect sizing, over cycling, and even if there is excessive stiction. However it is necessary to access the valve diagnostics through an asset management program to get detailed valve diagnostics.
 - Smart Valve positioners can analyze basic loop tuning problems by looking at the setpoint but cannot determine whether the problem exists with the sensor or with the loop tuning.
 - The ability to share data between both systems will allow for more accurate indication of where the problem exists and how to resolve it.



Summary

- Today's level of diagnostics are capable of helping plants to save money while increasing their process output.
- New diagnostic improvements are focusing on simplifying diagnostic analysis so the correct decision can be made without expertise.
- Advancements will continue to improve the accuracy of diagnostics with more measurement capabilities.
- Devices in your plant may already be collecting these diagnostics for you:
 - Devices with Embedded online diagnostics are continually monitoring your valves so you may have a lot of information just waiting for you to look at it...



Thank You

Questions, Comments