Valve IIoT & Remote O&M

- Markets
- Valve IIoT Programs
- Condition Monitoring

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Markets

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The Role of High Performance Valves in IIoT

- The Industrial Internet of Things (IIoT) will radically change the valve routes to market and valve revenues. With a projected growth rate of 13 percent IIoT will be responsible for valve revenues of $50 billion by 2030.
- If general purpose valves are the foot soldiers of IIoT then high performance valves belong in the armoured division. Their performance is much more critical to the outcome of the battle to improve plant performance. IIoT promises to revolutionize industry but only if it is accompanied by IIoW (Industrial Internet of Wisdom). Decisive classification of high performance valve applications, designs, and materials is critical to IIoT success.
- IIoT will generate continuous performance and condition information about each valve. A large plant could have 10,000 valves. In order to determine which valves are working best it is necessary to divide the applications and valve types into meaningful groups. One can then compare the performance of valves from different manufacturers in the defined group.

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High Performance Valve Classification

A high-performance valve is one which is in any of following three types of service.

- Severe Service: Corrosion, pressure, temperature, process operating fluctuations are all conditions that qualify an application as severe service.
- Critical Service: Safety, product purity, continuous operation, and product toxicity are criteria of critical service.
- Unique Service: The distinction is often made between an engineered valve versus an off the shelf or standard valve. In any case, the decision making for unique service valves needs to be made with prioritization of the lowest total cost of ownership.

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Total Industrial Valve Revenues in 2030

World Industrial Valve Revenues – 2030 - $ billions			
Revenue Source	Total	General Performance	High Performance
Total	90	40	50
Old route to market	40	18	22
New route to market (Remote O&M)	30	13	17
Additional Revenue (IIoT)	20	9	11
Revenues attributable to IIoT and Remote O&M	50	22	28

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High Performance Valve Sales to 3rd Parties will be $17 billion

- High performance valve sales of $17 billion in 2030 will be made to third parties. The IIoT additions to the valve offerings will boost revenues by $11 billion. As a result, the high performance IIoT valve market will be $28 billion.
- The market share for a specific supplier will be shaped by not only the quality of his smart high performance valve but his willingness to assume a greater role. At the very least he should develop his own remote monitoring center and provide analytics and wisdom at higher levels. The levels as defined by Honeywell are shown in the following chart.

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Digital Process Management Levels (Honeywell)

Level	Device	Function
1	Smart Sensors	Sensor and actuator with no or small amount of local processing and data storage
2	Edge Device/Smarter Connected Sensor	Includes a sensor, some local processing, data storage, power management, connectivity, security and user interface
3	Local system/ Connected Edge	Connect to a gateway, controller or server. Connectivity is mostly local in a closed loop system, could have cloud connectivity
4	Cloud Infrastructure	Allows data to be accessed, aggregated, stored monitored and actuated anywhere in the world
5	Big Data Analytics	Servers with cloud connectivity gather data for advance applications e.g. data analytics, visualization, machine learning

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Scope Hierarchy

There is also a scope hierarchy which influences potential IIoT. Valve suppliers can seize the opportunity to expand their scope by offering Level 3 programs.

Hierarchy	Deliverable	Level
1	Flow control component products such as valves and pumps	1-3
2	Processes. e.g. separation, reaction, heat transfer, combustion	1-4
3	Systems e.g. ultrapure water steam generation, wastewater treatment	1-5
4	Plants e.g. refineries, power plants, pharmaceutical, semiconductor	1-5

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Who will Capture the Largest Scope?

- A large valve supplier e.g. Pentair or a valve supplier with automation divisions e.g. Metso and Flowserve, a valve supplier which is part of a company also selling processes, systems and or plants, e.g. GE, Wärtsilä, has the opportunity is to be a Level 5 provider.
- At the very minimum the valve supplier has to design his valve for smart sensing. He also should supply the sensors. At Level 1 he can sell to suppliers of processes. But by teaming up with Honeywell, Rockwell, ABB, Schneider Electric, Yokogawa or other Level 2 & 3 providers the valve supplier can play a more important role. The insights he will receive will allow him to improve his valve products for specific applications.
- The valve supplier can better improve his products with the support of what are called “subject matter experts” of the IIoT community. It can be argued that subject matter expertise needs the same degree of organization (IIoW) as IIoT.

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High Performance Decision Guides – Oil & Gas

- One example of this is a series of Decision Guides on specific high performance valve applications which is being assembled by McIlvaine.
- Three of the most challenging applications for valves in the oil and gas industry are molecular sieve switching, flow control in oil and gas drilling, and gate valves used at greater than 5000 psi.
- When switching from one dehydration sieve unit to another zeolite particles are entrapped in the gas stream and create valve problems.
- The choke valves used for control in drilling are subjected to sand and other abrasive particles. In addition, the temperatures and pressures can be high.
- Gate valves used in hydraulic fracking and subsea operations at pressures greater than 5000 psi are operating in a tough environment where selection of the right designs and materials is critical.

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High Performance Decision Guides – Power

- In the power industry most new coal fired boilers are operating in the ultra-supercritical range.
- Valves are typically subjected to temperatures above 750F. These plants are quite large (up to 1000 MW). So any downtime is quite costly.
- Heat recovery steam generators used with gas turbine plants are often required to stop and start hundreds of times during the year. This rapid cycling is encountered where gas turbines are providing the backup power to solar and wind. This cycling has created a unique flow acceleration corrosion (FAC) problem.
- Decision Guides are being continually expanded in these four areas and will serve as an example of what can be done to further valve IIoW.

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Valve Market 2017-2015

World Industrial Valve Revenues $ billions		
Segment	2017	2025
Traditional route to market	55	71
New route to market	4	10
New smart revenues	3	7
Total	62	88
IIoT Impacted Market	7	17

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High Growth for Smart Valves and Remote Monitoring

The traditional market will grow at 3% per year. However, the new route to market through remote O&M will grow at 13%/yr. as will the additional revenues generated by smarter valves.

World High Performance Valve Revenues $ billions		
Segment	2017	2025
Traditional route to market	30	42
New route to market	2	5
New smart revenues	1.5	6.5
Total	33.5	53.5
IIoT Impacted Market	3.5	11.5

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Thousands of Continually Updated White Papers

- Not only can valve companies boost Capex revenues for smart valves and Opex revenues for service and parts but they can acquire process data to help them design better valve products for specific applications. This proliferation of information about valve performance will serve as a giant resource of valve white papers. Proof of lowest total cost of ownership will be automatic.
- The valve companies who best leverage this process and valve performance knowledge will be the most profitable. Those focused on IIoT will achieve profit gains of 45% in the high-performance segment and 32% overall. While those who miss the boat will suffer profit decreases of 10%.

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Increasing Market Share and Profits

Valve % Profit in 2025 due to the Impact of IIoT and Remote O&M				
	High Performance Segment		Total (general and high performance)	
Factor	IIoT focused Valve Companies	Others	IIoT focused Valve Companies	Others
Increased Market Share	15	-15	10	-10
Smart Revenues	10	0	7	0
Increased Base Prices with Better Products	20	0	15	0
Profitability Impact	45	-15	32	-10

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Valve IIoT Programs

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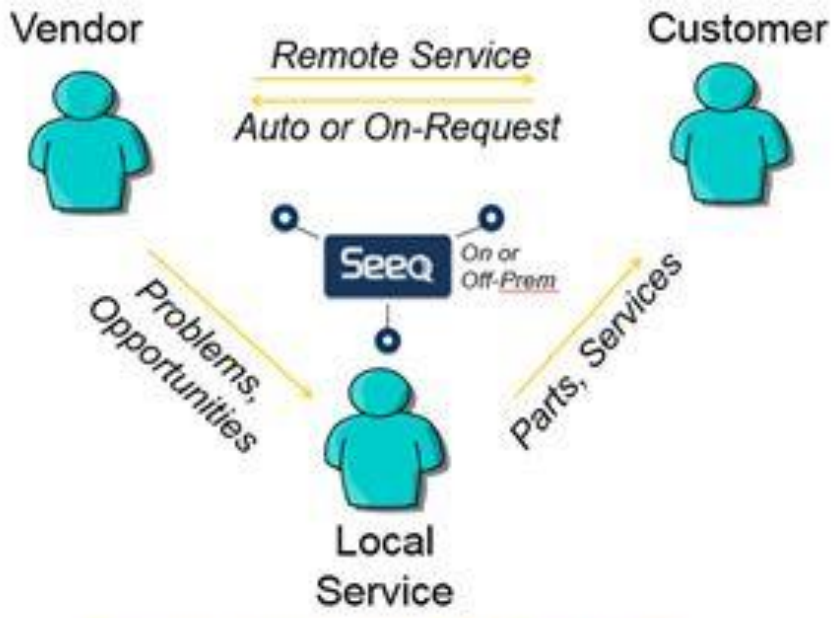
Emerson Valve Predictive Maintenance Program

Emerson Process Management, uses IIoT to help end users reduce valve-related unplanned downtime. Using IIoT, valve failure information is obtained directly from valves in aftermarket field installations. This approach uses predictive or prescriptive maintenance services to optimize customers' valve maintenance practices and prevent unplanned downtime for these critical assets.

Emerson partnered with software company, Seeq, to improve the data visualization tools used to predict future valve problems. Seeq used its expertise with time-series data to help Fisher Valve Division build a collaborative environment connecting customers with local Fisher services experts and global valve experts. This environment enables data from multiple sources to be visualized and aggregated. It allows authorized people located around the world to look and work on the same data for predictive maintenance and operational improvement



Taking Valve Management Programs to the Cloud

ValvKeep is a valve management system that allows you to keep track of all of the valves in your facility and along your pipeline. The data includes all valve history, including problems and repairs, maintenance work, documentation, and much more. By tracking your valve data, you can better predict when maintenance is likely to be required for individual valves. This helps you make repairs before you have a serious problem on your hands, and also decreases the amount of time and money you spend on unnecessary maintenance.

Allied Valve says “Now imagine how much more efficient your operations would be if the valves were connected and constantly streaming real-time performance data.”

“Currently, the main place we’re seeing smart technology is on control valves, where it’s used for diagnostics. As the IIoT evolves over the next few years, we’ll likely see smart technology be adopted for other types of valves and actuators, as well. It’s an exciting time.

ValvKeep benefits according to Chalmers and Kubeck

- Simplifies the requirement to have detailed inspection and test documentation since C&K uses a centralized database to store these records
- Immediate, 24/7 access to all critical valve data via a secure Internet portal
- Ability to identify trends in valve operation and maintenance that may allow lengthening of repair/test intervals based on “prior operating experience”
- Problem valves are easily identified by trend analysis to insure their frequency of repair/testing is appropriate.
- Assists in troubleshooting problem valves by highlighting specific valve repair history
- Automates equipment reports; harmonizes reporting formats.
- Provides complete visibility into the repair process, from start to finish.
- Helps to manage parts and spare valve inventories
- Provides a very effective planning tool for maintenance planning and scheduling
- The data provided by ValvKeep® is exportable and ready to use in other software applications

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Westlock Controls Intellis

Intellis is a family of fully-integrated control monitors that provide cost-effective valve automation and intelligent networking via all the major network protocols. “Features and benefits include

- Dedicated network modules (PACs) for all major protocols.
- Simple in-field conversion of network protocols.
- Multiple housing options (resin, aluminum, stainless steel).
- Models approved for all hazardous area applications.
- Control & monitoring for rotary and linear valves.
- Non-contact position monitoring via Hall effect sensors.
- Integrated pneumatic actuation control via pre-wired Falcon solenoid valves.
- On-line predictive and maintenance related diagnostics.
- Eliminates wiring cost of conventionally hardwired I/O systems.
- Reduces design engineering man-hours
- Range of drive shaft options.
- Visual indication Beacon available in a choice of styles and colors.

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Westlock Intellis Functions as Part of IIoT

- The Intellis family of industrial control field Network Control Monitors use embedded control systems to automate valves and link field I/O to the host PLC or DCS. A field network is a specified number of network monitors, interconnected by a common communications protocol. Each monitor is assigned a unique address and accepts input/output signals from valve position sensors, solenoids and external alarm and control devices.
- The Network Control Monitors are connected directly to either an electric or pneumatic actuated valve package and house two discrete Hall Effect sensors for valve position monitoring, a low-power solenoid valve for integrated actuation control, and a network interface module (Pac) for communication via a protocol of choice. Protocols supported include ASi®, DeviceNetTM, FOUNDATION FieldbusTM, PROFIBUS-DP and ModBus®. The network monitors communicate with a PLC, DCS or host computer via a gateway interface or scanner card having specific compatibility with the primary control network. Network Control Monitors are available for linear or rotary applications in all area classifications and Pharma II network control monitors are also available for sanitary applications in pharmaceutical and biotech facilities.
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Westlock Accutrak Wireless Monitoring

The specially designed wireless valve position monitoring system from Westlock provides real-time information about a valve's status directly into the control system, reducing failure and risk while increasing safety and yield. The claimed benefits are

- Reduced costs (wires, conduits, cable trays, cabinets, I/Os)
- Easier engineering and installation
- Faster commissioning and startup
- Solution for space constraints, smaller footprint
- Monitoring for manual, automated, rotary or linear valves
- Reduced unwarranted field trips and labor costs
- Improved operation efficiency and safety
- Multiple enclosure options (resin, aluminum, 316 SST)
- High visibility beacon and wireless valve monitoring (0 to 100%)
- 10 year battery life
- Intrinsically safe and explosion proof options
- Diagnostics and valve signature
- Direct mount to valves and actuators
- Easy integration with control systems

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Auma Cloud Program under Construction

AUMA Cloud and AUMA Support App are the company's approach to the Internet of Things (IoT), allowing users to collect and share in-depth information on all the actuators in their plants.

The Cloud program is under construction.

The AUMA Cloud is slated to be a dynamic information and knowledge platform as well as interactive network of experts. For advanced communication, more efficient processes and optimized performance there will be a

- Meeting Point For Experts
- Information And Documents Online
- Optimum Support

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Using Fuzzy Logic to Predict and Control Valve Performance

- Non-intrusive monitoring and diagnosis was applied to process control valves using artificial intelligence by fuzzy logic technique, contributing to the development of predictive methodologies identifying faults in incipient state. Specially in nuclear power plants, the predictive maintenance contributes to the security factor in order to diagnose in advance the occurrence of a possible failure, preventing severe situations. The control valve analyzed belongs to a steam plant which simulates the secondary circuit of a PWR—Pressurized Water Reactor. The maintenance programs are being implemented based on the ability to diagnose modes of degradation and to take measures to prevent incipient failures, improving plant reliability and reducing maintenance costs.
- The approach described in this paper (1)represents an alternative departure from the conventional qualitative techniques of system analysis. The methodology used in this project is based on signatures analysis, considering the pressure (psi) in the actuator and the stem displacement (mm) of the valve. Once the measurements baseline of the control valve is taken, it is possible to detect long-term deviations during valve lifetime, detecting in advance valve failures. This study makes use of MATLAB language through the “fuzzy logic toolbox” which uses the method of inference “Mamdani”, acting by fuzzy conjunction, through Triangular Norms (t-norm) and Triangular Conorms (t-conorm). The main goal is to obtain more detailed information contained in the measured data, correlating them to failure situations in the incipient stage.
- (1) Nuclear Energy Research Institute/National Nuclear Energy Commission (IPEN/CNEN—SP), São Paulo, Brasil

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Flowserve Domain Knowledge on Pumps and Valves and Honeywell Inspire™ provide IIoT Service

Honeywell (NYSE: HON) and Flowserve are collaborating to provide Industrial Internet of Things (IIoT) solutions to help industrial customers make their operations, safer, more efficient and more reliable. The collaboration is part of the Honeywell INspire™ program, Honeywell's joint customer development program for its IIoT ecosystem.

"The key to an effective IIoT ecosystem is to have three things," said Andrew Hird, vice president and general manager of Honeywell Process Solutions' Digital Transformation business.

- "First, you need to have secure access to the data being collected;
- secondly the capability to analyze that data;
- and finally, you need domain knowledge to understand how to deploy information to benefit the operation.

Flowserve's domain expertise in flow control solutions that include pumps, valves, seals and services is unmatched globally, which makes the Honeywell-Flowserve IIoT ecosystem unique for our customers.“

"We see this collaboration between Honeywell and Flowserve as beneficial to continuously improving how we serve our customers with the latest technology advanced software and analytics, and reliable services capabilities. Honeywell provides key infrastructure to collect and securely move data, while we embed decades of domain knowledge into predictive analytics for more business value, faster," said Eric van Gemeren, vice president, Research & Development, Flowserve. "This collaboration will help us provide our customers with new insight through transformative service capabilities that lead to more powerful decision-making and process optimization.

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Need to connect On-off Valves Including Solenoid Air Pilot Valves

- Most vendors of control systems have integrated diagnostics for electronic sensors and electronically actuated control valves. Simple on-off valves, like solenoid air pilot valves, have often been overlooked because it has been a standard assumption that these valves are not as important as control valves, or field sensors. Pneumatic solenoids have been bypassed or ignored for diagnostic purposes for years. But this will need to change, as all of the sensors and field devices in a plant become connected and smart. In the pharmaceuticals and biotech industries, validation and GMP issues have increased the demand for real-time diagnostic information. At the same time, the increasing use of skid-mounted production processes has made the use of dissimilar control systems a near certainty. This means that end users must insist on diagnostics in every I/O terminal, in every sensor, and in every final control element on their skid. I/O must have easy diagnostic information transfer using fieldbus. Festo's CPX/ MPA series provides a way to produce that.

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Pneumatic Solenoid Valves with Diagnostic Capability available from Festo

Both PLC and DCS control system vendors such as Emerson Process Management and Rockwell Automation promote diagnostics based asset management systems. It is possible to seamlessly interface any controller, I/O terminal, or pneumatic solenoid manifold into these systems but not all devices offer the same level of diagnostic feedback. Emerson's CHARM I/O connects HART compatible field devices and communicates diagnostics back to the control system and the asset management system. Other Emerson I/O does the same for Foundation Fieldbus. But CHARMs are not designed to handle control and diagnostics of solenoid pilot valves mainly because for many valve manufacturers that technology is lagging.

Another common platform is Rockwell Automation's RSLogix systems which can connect with various brands of I/O and field devices using Ethernet/IP, but when you start talking about pneumatics valves the same issue arises. Similar to the Emerson example, manufacturer technology in most cases limits the functionality of pneumatic pilot valves to a simple on/off control. The solution is to specify pneumatic solenoid valves with diagnostic capability, whether used for handling automation or piloting

Festo CPX/MPA will integrate with most leading PLC and DLC platforms and deliver uniform control and diagnostic information from the field, including I/O, I/P and pneumatic solenoid valves. The diagnostics is already built in due to an internal bus that runs thru the backplane of the pneumatics and I/O.

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Automation Supplier Resident Experts better for Pump and Valve Expertise than End User

(Arc white paper for Yokogawa)

- While IIoT-enabled asset monitoring and optimization can be performed internally within an organization at the local plant or enterprise levels, increasingly we're going to see IIoT-enabled functions performed remotely "as a service" by the automation suppliers' resident experts, the OEMs' experts, and/or third-party service providers. These experts typically have deeper understanding of the systems or equipment (pumps, valves, compressors, heat exchangers, reactors, distillation columns, etc.) than is available within the end user organizations.
- By combining this knowledge with advanced predictive analytics tools, the automation supplier and/or equipment OEM can provide end users with appropriate alerts and guidance, enabling them to avoid or mitigate the impact of issues or optimize their equipment and/or processes.
- As the knowledge base and expertise in industrial plants continues to erode due to corporate downsizing and retirements, these types of remote, supplier-provided services will become increasingly important for connected industrial enterprises. Yokogawa and other leading automation and equipment suppliers have already begun to develop and implement these important asset monitoring and optimization services for customers across a variety of industries – upstream, downstream, and midstream. This often involves close cooperation between the automation supplier, equipment OEMs, third-party partners, and the end users.

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Condition Monitoring

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Valve Condition Monitoring Systems

A valve condition monitoring system relies on sensors attached to or near the valve and actuator assembly to monitor their performance. This can be a combination of strain or pressure sensors that transmit data back to the operator for analysis. An ideal valve condition monitoring system provides a live measurement of the health of the valve, detects and predicts potential failures as well as identifies valves that are in need of overhauling or repair.

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Shell Ormen Lange provides Condition Monitoring for all Moving Components

- Ormen Lange is one of the world's most advanced gas processing plants but is operated by a skeleton crew. In fact, Shell's goal for the facility is to operate and maintain the plant with as few people as possible. In order to accomplish this, online condition monitoring systems are employed to monitor virtually everything that moves in the plant including pumps and compressors, control valves, certain structures and critical shutdown isolation valves. A stated goal for the plant is that 70% of the maintenance budget and maintenance spending should be based on the results of condition monitoring.
- *This data was in a paper by Stan Hale now with MRC but with Score Atlanta at the time*

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Condition Monitoring of the 41 most Critical Shutdown Isolation Valves

- Condition monitoring is used for the 41 most critical shutdown isolation valves at Ormen Lange. The population of critical valves includes a mix of single and double acting pneumatic and hydraulic gate, ball and flow control valves. These valves are instrumented with strain gages, pressure transducers and acoustic leakage sensors.
- The sensor data is continually streamed to a data acquisition system that combines other important data pulled from the plant's distributed control system (DCS) such as command signals, limit switch signals and upstream and downstream system pressures to create a complete picture of what is occurring at the valve during operation.
- Acceptance criteria for key parameters such as thrust or torque output at various points in the cycle, stroke time, leakage and other critical measures are automatically evaluated by the valve monitoring system after each cycle and icons in the system display software provide a visual indication of current valve condition.
- The monitoring approach is essentially the same as having a motor-operated valve (MOV) or air operated control valve (AOV) diagnostic system continually attached to these valves at all times

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Leaks detected with Acoustic Emission Sensors

- A critical requirement of the Ormen Lange valve monitoring system was the ability to detect through-valve leakage after the valve closes. Through-valve leakage is one of the most important test parameters for the oil and gas industry and certain valves must be tested periodically to verify they will not leak when needed in an emergency. Broadband acoustic emission sensors are employed by V-MAP to detect the high frequency noise caused by very small leaks at high pressure.
- The leakage noise elevates the broad band emission output of the sensor and also creates an initial peak above 100 KHz that spreads in both directions from the peak when the amplitude increases as a result of increasing leak size.
- The sensors and amplifiers used in the field provide the conditioned data in a format needed for automated recording in a safe area away from the valves

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Challenge with Very Large Valves and High Pressures

- The actuators are hydraulic or pneumatic, pressure transducers installed in the supply lines between the hydraulic control solenoids and the actuator cylinder.
- The actuators and valves used at Ormen Lange are much larger than the typical nuclear plant valve. The isolation valves at the landfall accommodate the 30” pipeline from the subsea wells. The critical shutdown valves on the export side of the plant are 42” in diameter with a maximum gas pressure at the valve of 3,600 PSI.
- The hydraulic actuators for these large gate valves can easily apply greater than 250,000 pounds of force to the valve at the maximum hydraulic system pressure of 4,700 PSI. The leakage criteria for each valve vary by valve and application but the typical acceptance criterion is .02 Kg/sec and .05 Kg/sec. The leakage criteria seem tight but when converted to flow it would be over 100 liters per minute depending on the gas density. The acoustic sensors and signal processing used will detect a leak as low as .1 liters per minute.

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Data is Captured and Utilized within and without the Shell Network

- All of the data is captured automatically without user intervention. The data is processed and analyzed and the results made available through the site network, the wider Shell network and outside of the Shell network through the internet.
- The end result is continuous real time confidence in the condition of critical valves versus the unknown and often changing condition not detectable by periodic testing programs.
- Growing Adoption in Oil & Gas The growing adoption of on line valve condition monitoring in oil and gas closely mirrors what occurred in the nuclear power industry when portable valve diagnostic systems were first introduced.
- In the early days of adoption by nuclear plants the targets were problem valves known to directly affect safety or plant operations. In the Ormen Lange case it is about getting the most out of the plant at the highest level of safety.

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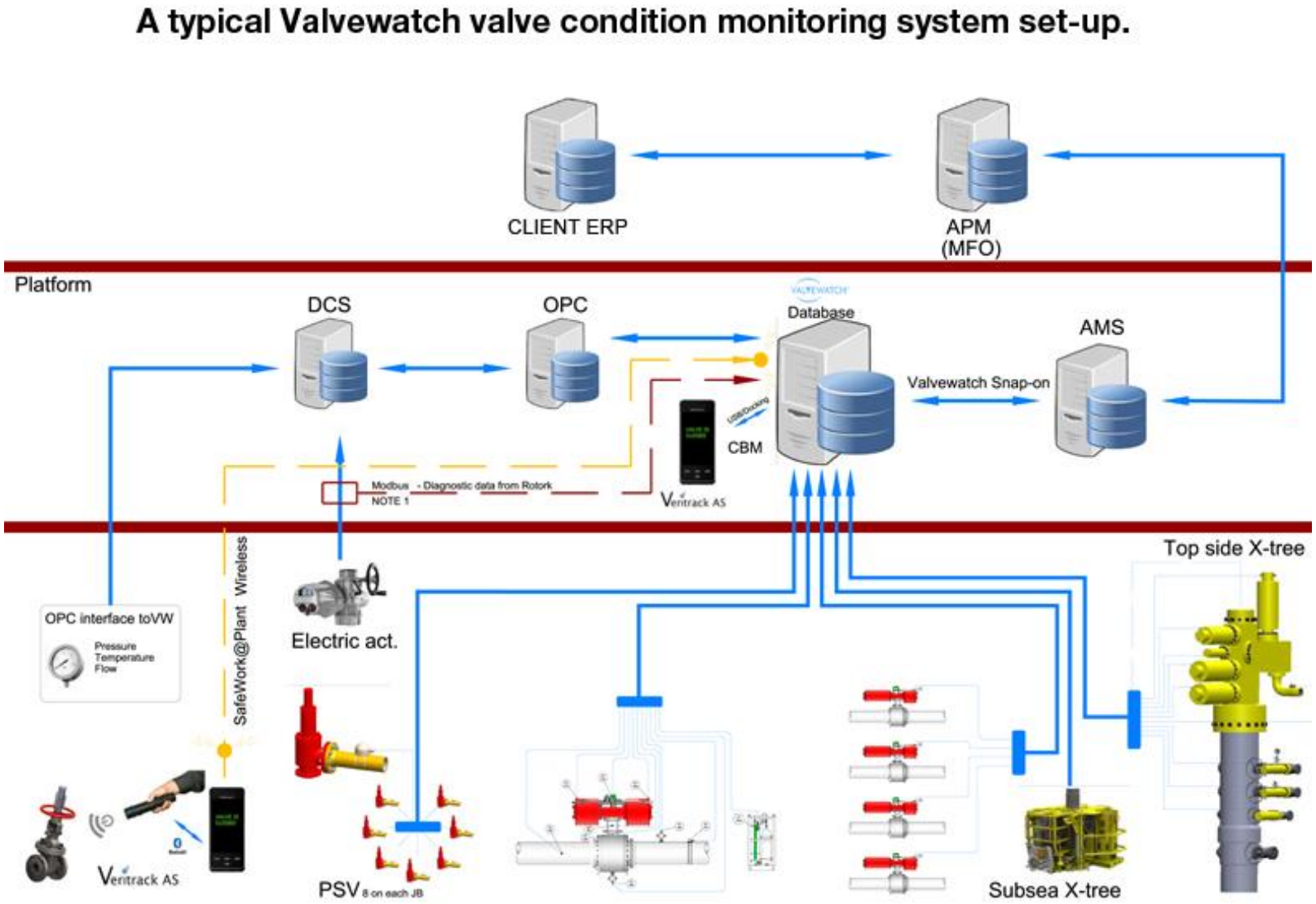
MRC Valve Watch



Benefits of a Valve Monitoring System (MRC)

- **Safety**
- In the energy industry, safety is paramount. If an emergency occurs, pipeline operators both on and offshore rely on critical isolation valves to operate successfully on-demand with absolute reliability. Critical valves may often be installed in remote locations, which can be difficult to access for manual testing and inspection. A failed valve or actuator can halt production without warning and create a dangerous situation for personnel. A valve monitoring system displays the real-time condition of these remote but vital valves and actuators, reporting problems before they create potentially dangerous situations.
- **Cost Savings**
- A valve monitoring system identifies valves that are in need of overhauling or repair. Today, valve maintenance is performed periodically, typically every one to two years. With active valve monitoring, valve maintenance practice can be moved from a corrective maintenance plan into a predictive maintenance plan based on the development of key maintenance parameters. Valve monitoring can allow these to extend to longer intervals.
- The system can also save costs by identifying which valves are in good condition and, therefore, need no replacement or service. Identifying problems early also gives the operator the ability to plan for the required maintenance and spare parts before it becomes an emergency. This increases the "uptime" for a facility or pipeline and reduces production loss.
- In incidents where the plant experiences an unplanned shut down, a high quality monitoring system will capture the full operational status and condition of the valve. This test can be utilized as a full proof of functionality, and be directly input into Functional Safety Management reports. This is a valid, cost-effective substitute for scheduled testing.

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Risk Management Benefits

- Identifying undetected faults in a valve is another benefit. There are basically two types of faults that can occur with a valve: Dangerous Detected faults (DD) and Dangerous Undetected faults (DU).
- The Dangerous Detected faults can be detected by traditional inspection and standard test procedures (partial stroke, time the opening and closing event, etc.). The DU are the faults that may occur which will inhibit the valve from moving to the fail safe position. These faults are seldom found without a condition monitoring system.
- To preserve the safety of both people and production “uptime,” our goal is to move as many DU faults into the DD “area” as possible. A valve monitoring system can do this.
- In Norway, a valve condition monitoring system is recommended on every offshore platform because of the potential safety risk an improperly maintained valve can create. But this technology can also be utilized in the onshore environment.
- *These benefits were listed on the MRC website by Tore Juvik*

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