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Online Valve Monitoring at Ormen Lange

The Ormen Lange Plant on Nyhamna Island, Norway.

The Ormen Lange Gas Plant provides up to 20% of the United Kingdom's natural gas imports. From the plant site on Nyhamna Island on the west coast of Norway the gas is transported across the North Sea via the Langeled subsea pipeline to the Easington Gas Terminal near the mouth of the River Humber on the UK's East coast. A/S Norske Shell operates and maintains the Ormen Lange plant. This article focuses on how online monitoring ensures the highest level of valve reliability and process safety systems at Ormen Lange.

By Stan Hale, Score Group

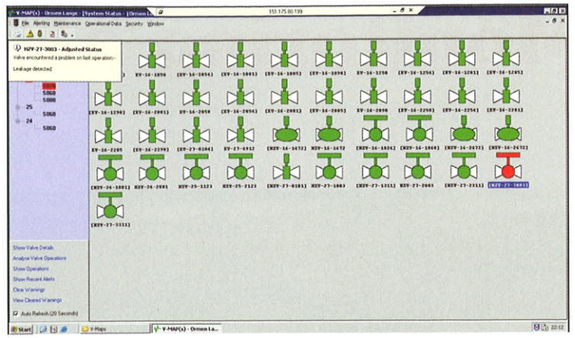
Ormen Lange is one of the world's most advanced gas processing plants but is operated and maintained with as few people as possible. In order to accomplish this, online condition monitoring systems are employed to monitor virtually everything that moves in the plant including the 41 most critical shutdown isolation valves.

A new twist on a proven solution

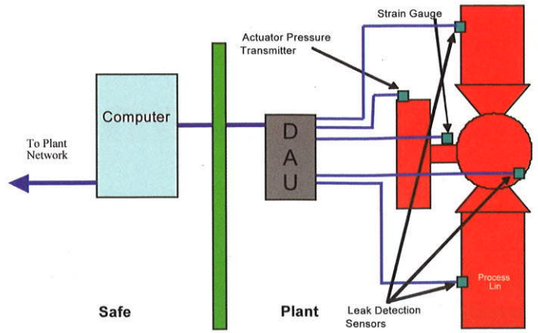
The population of critical isolation valves at Ormen Lange includes a mix of single and double acting pneumatic and hydraulic gate, ball and flow control valves. These valves are permanently instrumented with strain gages, pressure transducers and acoustic leakage detection sensors in order to monitor performance. 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 each valve during operation. Acceptance criteria for key parameters such as thrust or torque output at various points in the valve cycle, stroke time, leakage and other critical measures are automatically evaluated by the valve monitoring system 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 portable valve diagnostic system continually attached to these valves at all times. Score Atlanta has been assisting Shell in evaluating the on line results and performance of these critical valves for the past 3 years. The data is accessed from computers on the Shell network or remotely with the right permissions and the normal valve signature analysis process is used to evaluate condition. The approach taken at Ormen Lange illustrates how industries around the globe are adopting systems that make on line valve diagnostics and condition monitoring a permanent and critical element of safe operations and effective plant maintenance.

The successful adoption of diagnostic systems for valves in the nuclear power industry has been well chronicled in numerous industry publications and a wealth of information is available on the internet for those seeking information on valve diagnostics and condition monitoring. However, due to the absence of regulatory pressure, adoption of valve diagnostics has not been as wide spread in other industries when compared to nuclear. That trend is



The V-MAP Dashboard.



The V-MAP Functional Diagram.

changing at a fast pace. The move toward valve diagnostics and condition monitoring has moved fastest in the offshore oil & gas industry on the Norwegian side of the North Sea and after several years of experience with on line diagnostics, the current expectation among Norwegian operators is that critical valves must be monitored at some level.

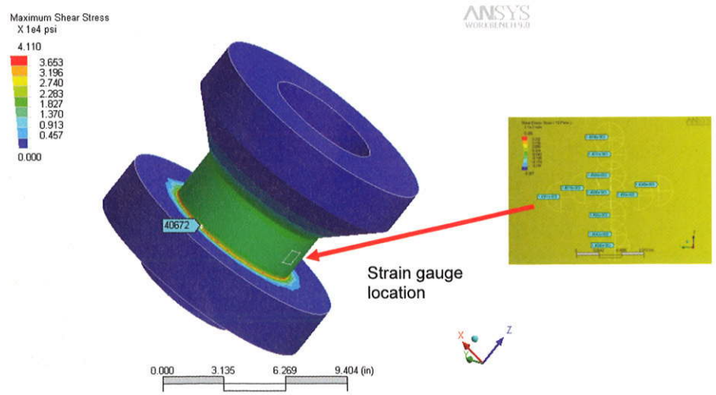
By 2003, at least a dozen Norwegian offshore platforms were monitoring critical isolation valves with on line monitoring systems. About this same time engineers designing systems and components and planning maintenance and operating strategies for the Ormen Lange Gas Plant were searching for industry best practices related to valves.

System design requirements

The Ormen Lange plant was designed and built to the highest safety standards consistent with IEC 61508 and 61511. IEC 61508 is applied during the design of safety critical systems to ensure that electrical, electronic and programmable equipment are analyzed such that the risks caused by failure of systems or components to perform intended safety functions are minimized. IEC 61511 establishes requirements for the specification, design, installation, operation and maintenance of a safety instrumented system, so that it can be confidently entrusted to place and/or maintain the process in a safe state.

One over-riding strategy that helped guide the design and planning process was the need to minimize the number of people required at the plant for maintenance and testing activities yet maintain the required level of safety. As a result, heavy use of on line condition monitoring systems for as many components and process systems as possible would be employed. The strategy was clear and detailed specifications were developed for the valve condition monitoring system and multiple suppliers competed in the bidding process. The V-MAP on line valve monitoring system was one of the systems selected to meet the condition monitoring goals of the Project.

To reach the desired level of safety at Ormen Lange, features such as partial stroke controllers for valves were installed in addition to the condition monitoring system. Partial stroke systems facilitate periodic exercising of valves that cannot be closed during operations. As a result, valves that must remain open for extended periods of time such as those at Ormen Lange can be partially cycled and monitored at some frequency. Both valve and actuator condition are monitored and evaluated after every full cycle and valves that remain open for production reasons can be partially closed in order to evaluate potential changes in performance. Automated on line data acquisition takes the human element completely out of the process and test opportunities cannot escape the continuous monitoring process.

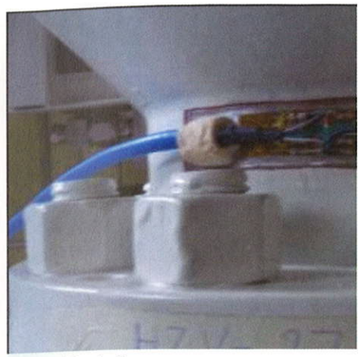


FEA of Ball Valve Mounting Stool.

Introducing V-MAP

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 with increasing leak size.

The leakage criteria for each valve vary by design and application but the typical



Installed Strain Gauges.

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.

As discussed above, the monitored valves at Ormen Lange include a mix of single and double acting pneumatic and hydraulic gate, ball and flow control valves similar to globe valves. The strain gage sensors detect changes in actuator output or loads in the valve that may affect performance. The precise location of each strain gage was determined by finite element analysis (FEA). The FEA identified the best location for the gage and the appropriate conversion factors for converting strain to torque or thrust. The strain sensor data is used to evaluate changes in running force on gate valves or torque on quarter-turn valves that would affect the available margin to operate the valve. Some minor changes in torque have been observed over the first 3 years but not to a level that would challenge the ability of these robust actuators. By evaluating the relationship between hydraulic pressure and force/torque from the strain sensors, the analyst can assess changes in the valve and actuator and determine the location of the observed degradation.

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. The V-MAP data acquisition units (DAUs) capture multiple channels of sensor data streaming from the acoustic emission sensors, the strain gages and pressure transducers attached to each valve. The DAUs then stream the captured data in digital format from the sensors to a server in a remote location. Data from the plant control system is time synced to the field data in the server via an OPC link. The plant data includes time stamps for initiation of the valve cycle, limit switch actuations, system pressure at the valve and differential pressure across the valve when the valve is closed.

The V-MAP application running on a server provides automated analysis of the incoming data based on user defined limits in the software. When acceptance criteria are not met the V-MAP user is alerted at his workstation when viewing the main V-MAP dashboard. The visual icons representing each valve change from green to red or yellow based on automated analysis of the data. After 3 years of monitoring, the acceptance criteria for force or torque, cycle time, response time and leakage have been adjusted to reflect the baseline performance at various operating conditions and to help automate online evaluation of changes over time.

The valves with partial stroke control systems are exercised regularly and the data is automatically captured and evaluated by the system. Since the valves do not fully close, only minimal diagnostic information about the condition of the valve is gained from a partial stroke test. However, the partial stroke limit switches play an important role relative to stroke time. The amount of time required between the close command, the release of the solenoid, the valve starting to move and then reaching the partial close limit is recorded and trended. Changes in these times could be indicative of changes in the hydraulic system, changes within the actuator or changes within the valve.

The simultaneous recording of the strain and hydraulic pressure sensor data helps to isolate whether the change was due to changes within the valve or actuator. 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.

V-MAP around the world

V-MAP valve monitoring systems have also been installed on offshore platforms in the North Sea and in the US Gulf of Mexico to monitor critical valves and known problem valves. Similar systems have also been installed on offshore platforms in the Malaysian waters of the South China Sea and most recently in the Tar Sands of Northern Alberta. In all cases the goals were very similar; to obtain the highest level of confidence in valve reliability at the lowest possible cost. The on line approach allows each valve to test itself and alert someone when something changes for the worse. As a result, condition is accurately reflected by the monitoring system and maintenance performed long before degradation can challenge the proper operation of continuously monitored valves.

About the author

Stan Hale tested his first valve at a nuclear power plant in 1985. Since then, he has provided valve program support at some level for most nuclear power plants in the US and many worldwide. Stan is a long term member of the ASME nuclear power plant O&M code committee on motor-operated valves. Stan holds a bachelor's degree in economics from Kennesaw State University and is currently president of Score Atlanta, Inc., a subsidiary of Scottish energy services provider Score Group, plc.