An Improved Method of Testing ESDVs on Offshore Platforms

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ABSTRACT

Monitoring the condition of emergency shutdown valves (ESDVs) on offshore oil and gas platforms is an essential part of maintaining the safety of personnel and protecting the environment. Riser and export line ESDVs in particular are intended to block the flow of hydrocarbons in the event of a line break or fire. Failure of ESDVs to operate properly increases the risk to personnel, the environment and production asset. In order to reduce risk, these valves must be tested at regular intervals to ensure they will function on demand and provide the necessary leak-tight shutoff. ESDV test requirements vary from monthly to annually depending on regional regulations.

Murphy Oil has recently begun evaluating a new monitoring system that enables continuous online testing for ESDV seat leakage (passing) while the valves remain in the full open, full flow position. ValveWatch™, the online ESDV monitoring system was initially developed for use on the high production rate platforms in the North Sea. Statoil teamed with Norsk Hydro and CRANE Valve Services to develop a monitoring system and related technology that would meet the demanding regulatory requirements for ESDV testing with minimal impact on platform operations and production output.

ValveWatch™ systems were installed on Murphy's West Patricia platforms offshore East Malaysia near Bintulu in August 2005. The ValveWatch™ system checks each valve for leakage (passing) on a daily basis and when monitored ESDVs operate, the monitoring system captures critical performance data that can be used to assess overall valve and actuator condition. The valve seat integrity data combined with the actuator performance data recorded during routine operation enables platform operators to develop a complete picture of ESDV condition and ensures lower probability of failure on demand.

This paper describes how ESDV leakage and performance testing is being employed by Murphy Oil in Malaysia to satisfy safety regulations, reduce the maintenance workload while improving availability and production output.

BACKGROUND

Following the Piper Alpha accident, the Norwegian Petroleum Directorate (NPD) increased pressure on oil companies operating in the North Sea to verify, through periodic testing, the ability of critical ESDVs to perform as required during an emergency. Statoil and Norsk Hydro struggled with the impact of ESDV testing requirements on production output and the increased O&M cost due to the testing process. As a consequence, Statoil, Norsk Hydro and CRANE Valve Services collaborated on the development of an automatic online condition monitoring system for ESDVs. The ValveWatch™ system is the result of that collaborative effort. ValveWatch™ systems are currently installed in Norway at the Kollsness onshore receiving station and offshore on the Gulfaks, Huldra, Oseberg East, Kvitebjorn, Sleipner and Grane platforms.

ValveWatch™ monitors the condition of ESDVs during normal production to determine if the valves are leaking and to estimate whether the leakage is above the capacity of the fire protection system. The term "ValveWatch™" refers to the entire system – both hardware, software and network communications to an onshore monitoring center – that is required to monitor a valve.

ValveWatch™ employs dynamic pressure sensors and strain gages attached to the valve to develop a complete picture of valve and actuator condition. A simple block diagram of the ValveWatch™ System is provided in Figure 1.

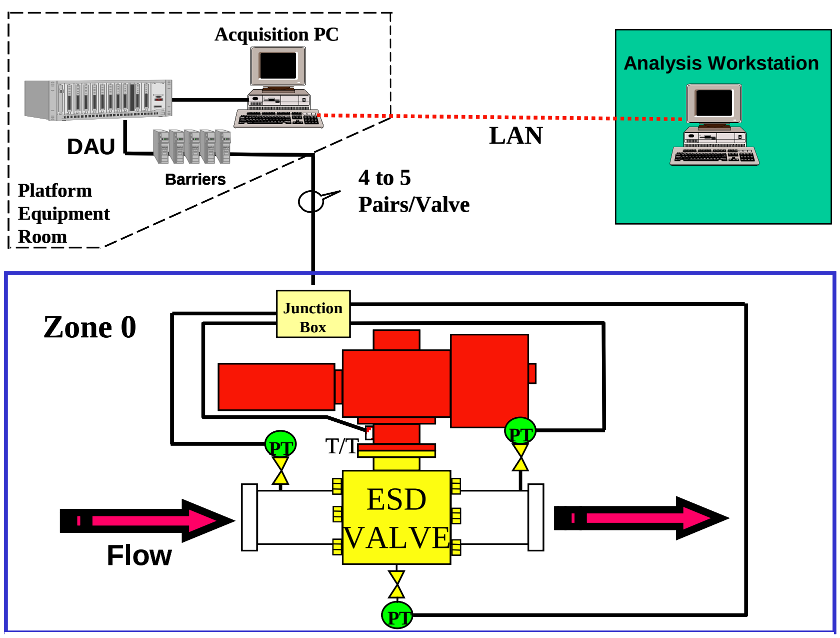

Figure 1
ValveWatch™ System

The dynamic pressure transducers monitor the pipeline and valve cavity pressures for fluctuations due to noise or vibrations in the flow stream. Fluids and gases flowing through an oil or gas pipeline generate pressure variations on top of the static pressure. This is more commonly known as flow noise. ValveWatch™ takes advantage of this flow noise to determine if a valve seat is leaking when the valve is in the open or closed position.

Strain gages are also attached at the valve-actuator yoke connection to measure torque or thrust required to operate the valve. (A ball or butterfly valve requires torque actuation and any rising stem valve, such as a through-conduit gate valve, requires thrust actuation). The software converts the strain gage's output into a graphical depiction of the forces experienced by the valve at various points while it is stroking. By knowing the characteristics of the valve and comparing successive traces, the ValveWatch™ monitoring center analyst can easily determine if the mechanical condition of the valve is deteriorating.

WEST PATRICA FIELD EVALUATION

In August 2004 Murphy engineering and operations personnel attended ValveWatch™ demonstrations at the Metronet SDN BHD facility in Subang (Metronet is the authorized CRANE ValveWatch™ agent in Malaysia). The demonstrations included live remote monitoring of a valve in the United States via an internet connection and practical demonstrations of the ValveWatch™ leakage monitoring technology on the Metronet flow loop.

The demonstrations were followed by a series of meetings and discussions on the feasibility of a trial or pilot on Murphy's West Patricia development offshore East Malaysia near Bintulu. Murphy subsequently gained the required internal and external approvals and began preparing for the pilot installations in early 2005.

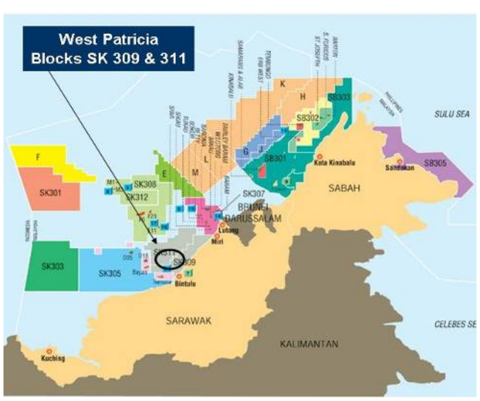

Figure 2
West Patricia Location

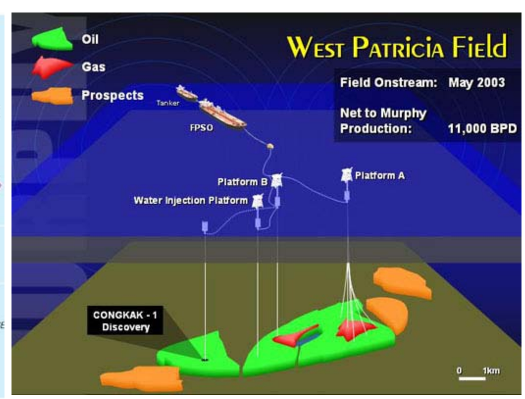

Figure 3
West Patricia Development

The West Patricia development includes three platforms (WPPA, WPPB and WPIA) and an FPSO (WPFA). Seven valves, three on WPPA, two on WPPB and two on WPIA were identified for the trial program. WPPA was selected as host location for the ValveWatch™ server. Independent ValveWatch™ data acquisition units (DAUs) were installed on each platform (see Figure 4). Murphy's existing network infrastructure facilitates communication between the platform DAUs, the WPPA server and to Murphy's Kuala Lumpur (KL) office through Bintulu. CRANE monitoring center analysts access the WPPA server over a secure VPN connection.

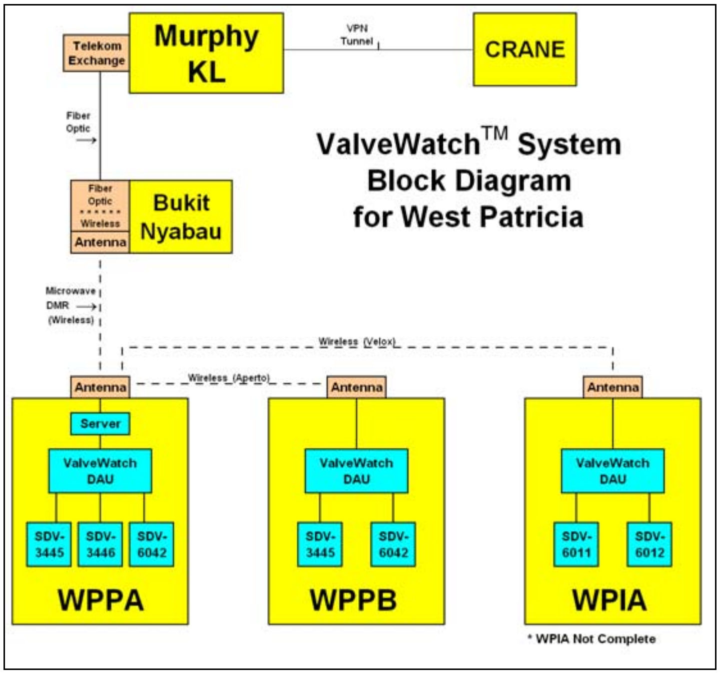

Figure 4
Pilot Network Infrastructure

The purpose of the West Patricia ValveWatch™ pilot is to evaluate the effectiveness of ValveWatch™ at verifying valve seat condition (detecting passing), monitoring actuator operational readiness and to assess the overall robustness of the product hardware and software.

Murphy, Crane and Metronet began preparing for the West Patricia installation in January 2005. Between February and July engineering documents were prepared and drawings modified to reflect the planned installation. Crane delivered the ValveWatch™ Data Acquisition Units (DAUs), sensors and computer in July 2005. Junction boxes and cable were procured by Murphy.

The installation activities were coordinated around the planned field shutdown in August 2005. The valve cavity take-offs, pipeline take-offs and sensor installations on WPPA and WPPB were completed during the shutdown. Cable installation began just prior to the shutdown and concluded before restart. The junction boxes, DAU installations and wiring terminations were completed after restart.

The WPPA and WPPB systems have been operating continuously since startup in early September. The WPIA DAU is installed but waiting sensor installations that have been delayed until a future shutdown.

Installation and Start-up

The initial system set-up was performed on each platform and ValveWatch™ executed the learn-mode routines for the pilot valves automatically. All subsequent analyses and adjustments were performed from the Crane Monitoring center in Kennesaw, Georgia, USA. The 5 valves on WPPA and WPPB have been thoroughly analyzed and are being monitored daily for leakage and other adverse trends.

Figures 5-7 identify typical sensor installations on West Patricia to facilitate ValveWatch™ monitoring. The sensors are terminated in a junction box near the valve and routed back to the WPPA control room through cable tray.

Figure 5
Strain Gage and Cavity Sensor

Figure 6
Upstream Pipeline Sensor

Figure 7
Actuator Supply Pressure Sensor

The five pilot valves exhibit classic ValveWatch™ noise patterns from the cavity and flow stream sensors. Figure 8 illustrates the relationships between flow noise and cavity noise when the valve is in the full open position and crude is flowing through the pipeline. Note the quiet cavity (Blue trace in center) and the noisier pipeline (Green). When the valve seats degrade and begin to allow passing, the frequency content and amplitudes of the two signals become more similar. The change is not always obvious during simple visual analysis so leak detection algorithms and automated routines contained in the ValveWatch™ software are used to detect these subtle changes.

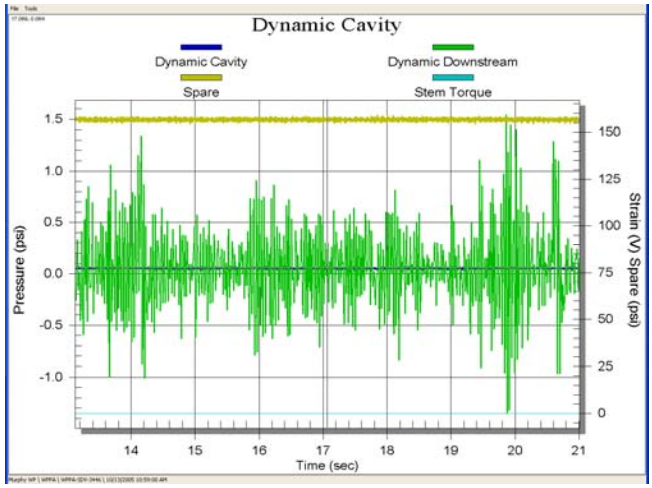

Figure 8
Downstream Pipeline and Cavity Sensor Overlay
(Valve Open)

Figure 9 represents raw data from a normal ESDV closure. Actuator supply pressure to the piston is shown in the spare channel. When supply pressure is removed from the piston the actuator's spring assistance in the closing direction applies torque to the valve stem which is detected by the ValveWatch™ strain sensor. Once the valve port opens the cavity flow noise is detected by the cavity sensor. Flow noise through the cavity reaches a peak when the valve is in mid-position. Once the port rotates completely past the valve seats the cavity and pipeline sensors become quiet indicating flow has stopped.

When both seats are damaged and allowing passing through the valve cavity, the cavity sensors continue to indicate high noise levels through the cavity after closure. The data in Figure 9 indicates the valve seats are not allowing passing during this test.

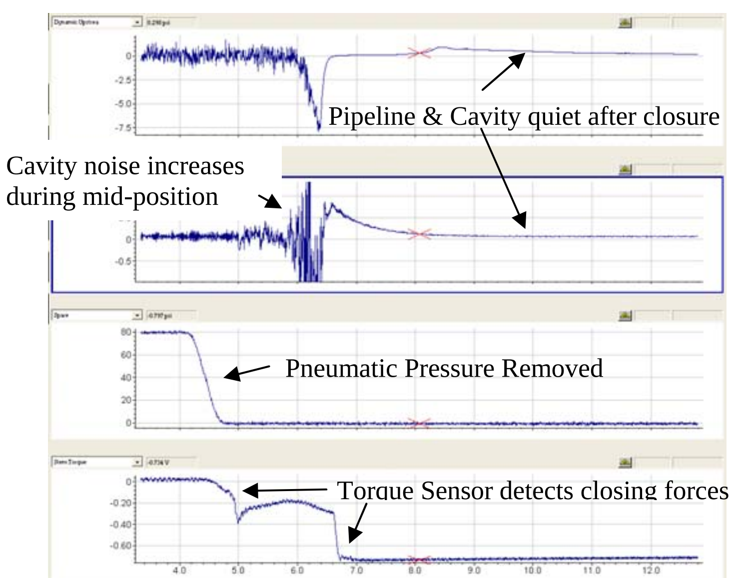

Figure 9
SDV-6042 Closing Cycle

Lessons Learned from the ValveWatch™ Pilot

ValveWatch™ System installation and start-up was completed as planned for WPPA and WPPB. The WPIA installation will be completed during a future shutdown. The WPPA and WPPB ValveWatch™ systems are functioning properly except for occasional power interruptions that take the WPPA server off line. The server must be manually restarted to establish communication with the DAUs and with the Murphy network. ValveWatch™ servers in the field should be powered by an uninterrupted power supply (UPS) to avoid communication loss and manual computer restarts in order to achieve complete hands-off monitoring.

ValveWatch™ uses an initial test sequence called "Learn Mode" to build the noise profile for each valve under normal operating conditions. The Learn Mode statistics are used to establish the acceptance criteria for future automated tests. An accurate Learn Mode testing series was not initially acquired for one valve on the WPPA platform. The upstream sensor output changed before the learn process was complete suggesting the learn tests may have been obtained while the pipeline sensor was not working correctly. Figure 10 reveals a change in pipeline flow noise that occurred on 9/9/2005. The pipeline sensor was presumed to have become clogged as a result of the vertical installation orientation (See Figure 5 above). Field troubleshooting was required to assess performance of the pressure sensor.

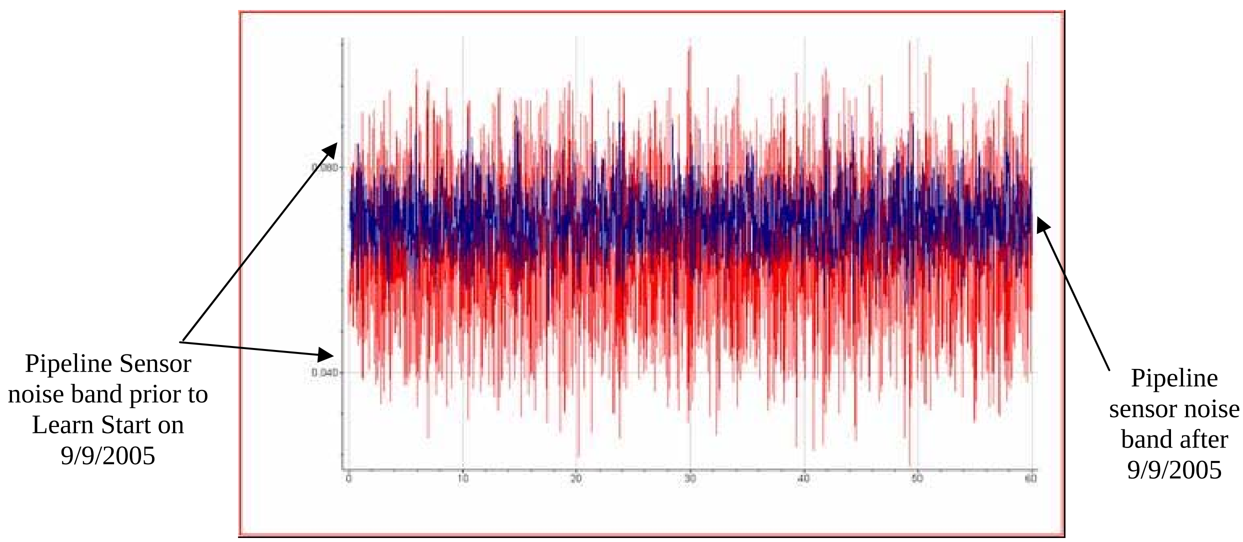

Figure 10
Change Detected in Pipeline Flow Noise

In early December 2005, Crane Valve Services dispatched an engineer to troubleshoot the pipeline sensor on this valve. Removal of the sensor verified the suspected clogging of the path between the pipeline and the sensor. A fine silica or sand had settled above the sensor which obstructed detection of pressure fluctuations. The tubing between the take-off and sensor was modified so that this sediment could accumulate below the sensor and could be easily cleared by maintenance.

Figure 11
Clogged Take-Off

Figure 12
Sensor

Figure 13
Modified Configuration

A nonfunctional static pressure sensor was also investigated by the Crane engineer while on site. This particular sensor had not worked since the initial installation and it plays a role in the analyst's decisions on actuator condition. Removal of the sensor cover revealed that water and other debris had penetrated the sensor's electrical compartment. Again orientation of the sensor was found to be critical to long term performance. Figures 14 through 16 identify the installed orientation with the cable penetrations facing upward, the condition of the sensor compartment and orientation of the replacement sensor.

Figure 14
Clogged Take-Off

Figure 15
Sensor

Figure 16
Modified Configuration

It is clear from these two examples that the ValveWatch™ sensors are sensitive to installation practices including orientation and protection from the environment.

Conclusions

The learning process necessary to adjust leakage thresholds will continue through the first three months until a robust set of performance data is obtained and all of the various operating conditions and flow rates through the valves are well understood. At that time the system will operate automatically with little user intervention.

The pilot period is expected to conclude by the end of December 2005. The CRANE ValveWatch™ Monitoring Center will continue to collect and analyze all scheduled and triggered valve performance test results and maintain the ValveWatch™ data and set points for the West Patricia installation. The performance data is evaluated daily by skilled analysts and automatically posted to a database that is readily available to authorized Murphy personnel via the Internet.