REDUCING RISKS AND AVOIDING LEAKS

Olav Brakstad, ClampOn, Norway, examines the 'silent revolution' of acoustic valve leak detectors.

Recently, the media has more frequently reported about incidents caused by leaking valves, both onshore and offshore alike. If there is a leak to the atmosphere, the risk for safety and the environment is substantial. Even if a leak is internal only, for example through a passing valve, there is still a risk for unsafe situations to occur. The cost of any situation where a valve is leaking quickly surpasses the cost of installing instruments and having an online continuous monitoring system in place. Existing maintenance and inspection programmes are often not up to the job of maintaining uptime whilst keeping inspection costs to a minimum, too often leading to high risk situations.

A modern oil and gas industry, with all its production facilities, process plants, refineries and pipelines, must take action to avoid unwanted leaks, unsafe scenarios and environmental complications. Some countries have implemented strict governmental regulations, where the operators are not only required to report the specific leaks, but also to report the quantities of the leak. Despite the presence of these regulations, they are not enforced in full. By using ultrasonic systems, the operators are able to comply with governmental regulations and keep safety at the highest level.

Over the last couple of years, an increasing number of oil and gas operators have realised the risk involved in having a passive approach to valve control (inspection only) and have started implementing a new principle into their maintenance programmes, through the installation of valve leak monitoring instruments and systems. Studies also show that there are significant savings involved in the identification and monitoring of critical valves. Several systems are available, some more advanced than others, and most make use of ultrasonic instrumentation as the main input of valve leak data.

ClampOn, who are more known for their sand detectors, is one maker of such acoustic based leak monitors. ClampOn can report a 'silent revolution' happening in terms of the installation and use of acoustic leak detectors. On several recent field developments where sand detectors would normally be the main scope of supply for ClampOn, they have actually installed several more leak monitors than sand detectors.

For ClampOn, the reason is clear: leaking valves have become more of a focus area, where the operators see the upside in both reducing risk and increasing uptime, effectively reducing cost through fewer inspections, not replacing well working valves and fewer productions stops. Several companies that have contacted ClampOn have reported challenges with their maintenance planning, as they often take in valves for service on the basis of suspicion of leaks, only to find that the valve is fully functional. A leak monitor could easily determine if a leak is present and the size of the leak, avoiding the unnecessary cost of inspection and valve replacement.

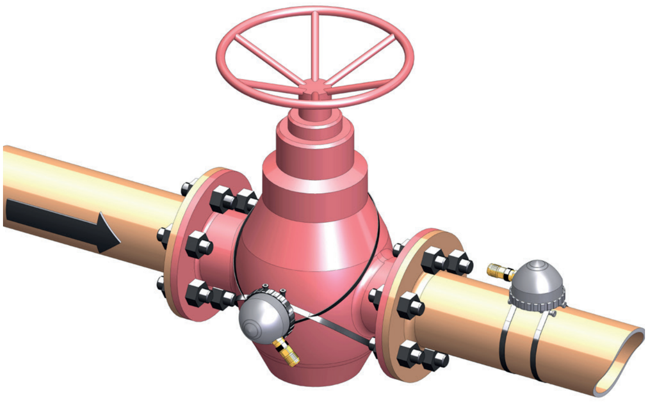

Figure 1. Recommended leak monitor installation locations.

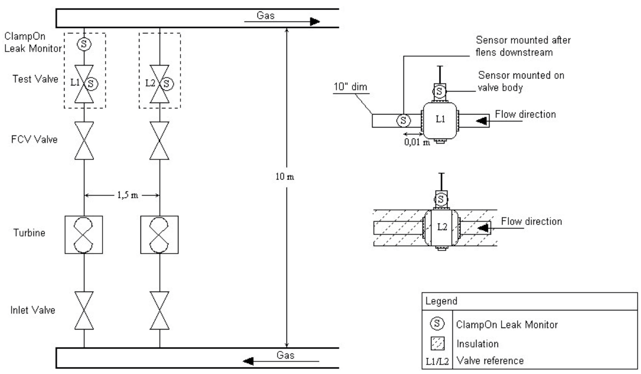

Figure 2. Valve setup on Kårstø.

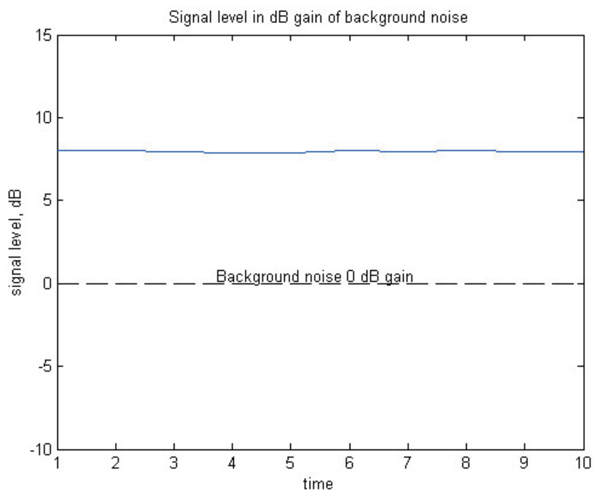

Figure 3. Leak through valve L1 when shut tight.

Working principle

A simple way of explaining how the instrument works is to look at the leak monitor as an advanced, high-tech microphone. The physical principle used to detect passing valves is based on acoustic emission. All valves that are passing will emit a frequency range with varying amplitude, depending on the volume of the leak. This noise or vibration can be detected by an acoustic transducer. The physical source of leak noise is the varying pressure field associated with turbulence in the flow. Turbulence is caused by flow instability where inertial effects easily dominate viscous drag. The instrument is simply installed onto a pipe, immediately downstream of the valve that requires monitoring, where it 'listens' to what is happening inside.

The best position is as close as possible to the source of signal generation. There needs to be good contact to allow for signal transmission between the valve and the transducer. The contact area between the component being measured and the transducer should be maximised. Where possible the measurement position should be a smooth, flat or large radiused surface. Preparation of the surface at the measured position is not normally necessary, but any loose paint or rust deposit that has de-bonded from the valve should be dislodged so that the transducer is coupled directly to base metal or firmly adhered surface. This means that there can be no insulation or air gaps between the measure point and the signal source.

In normal operation, while the valve is open, the instrument takes an ultrasonic photo within a range of frequencies. When the valve is closed, the signal, or noise picture, is measured again and a new photo is taken. If a closed valve is leaking, the noise picture will again be different to the original, indicating the presence of a leak. Based on the signal level reading, combined with differential pressure and the physical information about the valve and the line it is installed on, quantification of the extent of the leak can be obtained. From laboratorial testing conducted on approximately 500 different types of valves, a multiple regression analysis found a relationship that enables rate to be predicted based on the measured signal and knowledge of the valve size, valve type and operating inlet pressure. Leak rate is predicted in litres per minute (l/min).

In situ testing

ClampOn has also tested and confirmed their instruments' performance through multiple tests for various operators, both topside and subsea. All tests have confirmed the leak monitor's capability of detecting small leaks with great accuracy.

One of the many tests conducted was at the Kårstø processing complex and terminal in Norway. As the valves tested were two 10 in. gate valves, larger than the predictive leak equation, mounted in a closed loop, it was not possible to do leak quantification. Instead the effect of background noise from nearby low frequency equipment and parallel turbulent flow with the same outlet was examined, as well comparative readings from multiple measuring points.

Figure 2 illustrates the flow loop used for testing at Kårstø, which used butane as the test gas. This graph shows a typical detected leak through a valve, compared to no leak with 0 dB gain. By using the predictive equation for gas, the leak rate is calculated to be approximately 15 l/min.

First the background noise was measured and then the instrument level of the leak noise. By using the following formula, dB gain was calculated as it is presented in Figure 3. The dB gain of the background noise is zero.

$$Signal, dB = 20 \cdot \log\left[\frac{Instrument}{Background}\right]$$

Figure 4 shows the measured acoustic signal when valve L1 changes from shut to opened over the time period of 20 secs. The noise pattern can be seen to go from laminar to turbulent and back to laminar during this operation. From Figure 4 it is clear that the valve has to be shut tight in order to be able to investigate any possible leak. A partially open valve will create turbulent noise, similar to that of a leaking valve.

In Figure 5 there is still a small leak through valve L1, but now there is also a large leak through valve L2. The same background level as in Figure 3 was used when calculating the decibel gain.

Turbulent flow patterns from nearby bends and tubing can cause an acoustic signal that 'drowns' the actual leak signal. This can be avoided by implementing preventative actions, such as the positioning of the sensor and pre-investigation of the background noise. Tests show that identifying passing valves non-intrusively is an effective and cost saving approach.

Under such adopted test conditions, turbulent flow behaviour of the leaking flow can be regarded as the main source of acoustic noise. Low frequency equipment (<100kHz) has no effect when measuring the leak rate, but nearby turbulent flows can present difficulties.

An empirical equation has also been derived, both for gas and liquids, with the purpose of predicting the flowrate of the leak. This equation combines various process parameters such as inlet pressure, valve size, valve type and liquid viscosity, with the decibel gain of the measured acoustic signal.

Conclusion

Through real life examples, ClampOn has found that significant savings can be achieved by use of non-intrusive acoustic leak monitors for monitoring of valves. The predicative equation will not always give a 100% accurate result, but the error range will not be of critical importance and the quantified results will provide valuable information on the extent of the leak. The valve leak monitors are intended for permanent installation, doing real time, online, continuous monitoring. This will give the operator immediate warning when a closed valve is leaking as well as information about the extent of the leak. The instruments are available for both subsea and topside installation. The topside units come in both intrinsically safe (Ex i) and explosion proof (Ex d) versions, and carry relevant certification such as ATEX, IECEx and UL. The subsea units are made from titanium so as to last for more than 30 years at harsh subsea conditions and are qualified for water depths exceeding 3000 m.

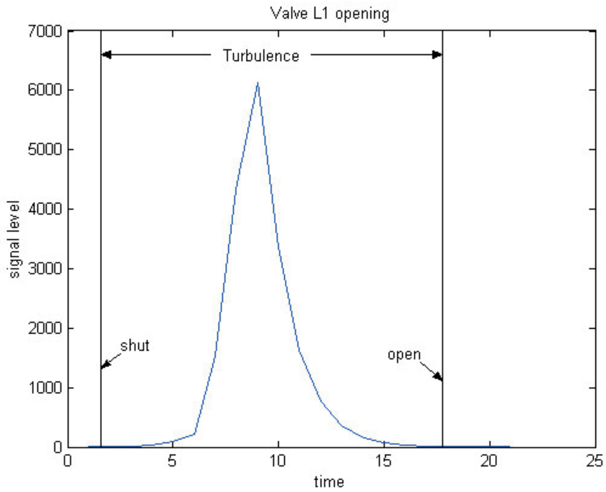

Figure 4. Acoustic response when opening valve L1.

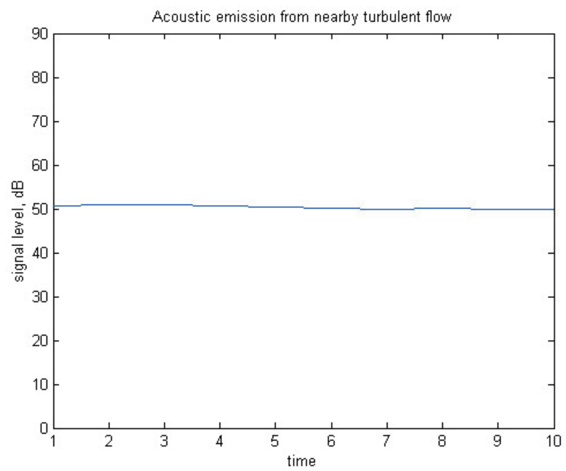

Figure 5. Leak through valve L1 with nearby turbulent flow.