



Guidelines for Use of Wireless Instruments for Valve Monitoring

Overview

Pressure relief valves are critical safety devices that act to protect equipment and personnel in the event of dangerous pressure build up in process piping and vessels. Normally closed, these devices are typically controlled by a spring force and have no auxiliary source of power. Therefore, these valves require a margin between the Maximum Allowable Working Pressure (MAWP) of the vessel or piping and the system operating pressure. Relief valve manufacturer's normal recommendation is that system pressure should not exceed 90% of valve set pressure (opening point), which is usually equal to MAWP. As the operating pressure approached the opening point of the valve, the valve will simmer or weep much like a tea kettle before the whistle blows. When the sealing surfaces are in good condition, emission and product loss is limited to release of excess pressure, however as time goes on a percentage of these valves will leak to atmosphere or waste collection systems that normally go to flare. These valves are usually mounted on the top of vessels and are often at inaccessible locations that require special equipment and safety procedures for in-situ inspections. The typical inspection approach is to schedule the removal and shop inspection of pressure relief valves on a time interval that is established based on historical or design criteria.

It is common to find that a large percentage of the valves fail seat-leak testing at their scheduled inspection. 30% to 50% of valves tested do not pass pre-installation criteria during these tests. 5% to 10% of them are leaking so severely that they have become major sources of lost product and possible emissions. With the cost of energy and petroleum products reaching new high levels and air quality becoming an increasing area of concern, continuous relief valve monitoring can be a source of improving productivity and achieving compliance with environmental standards. Wireless sensor networks enable new best practices of continuous monitoring. In particular, the application of wireless acoustic monitors is very effective for a large component of the installed pressure relief valve population. The same sensors can also detect leakage through isolation and by-pass valves for many service conditions.

Application of Wireless Instrumentation for Valve Leak Detection

Ultrasonic sensors have been successfully employed for many years in diagnostic procedures for evaluating equipment condition. Compressible and flashing fluids achieve sonic velocity at relatively low pressure drops. As the orifice size of flow area decreases, the fluid velocity increases. The orifice size of leaking valves is very small, and therefore, sonic flow will be achieved at low pressure differentials. In the case of valves which are normally closed, the detection of flow-induced ultrasound is an indication of valve leakage. The characteristic frequency of this flow is around 40 KHz. At lower pressures and flow rates, low levels of ultrasound can be detected by well designed acoustic sensors. As the energy increases with higher flow rates, a wide spectrum of noise will be generated including highly audible activity. Once leakage has begun, it normally continues until the valve seats have been repaired, increasing in severity with time and erosion of the sealing surfaces.



Wireless Acoustic Instrument

Attributes of Wireless Acoustic Instruments

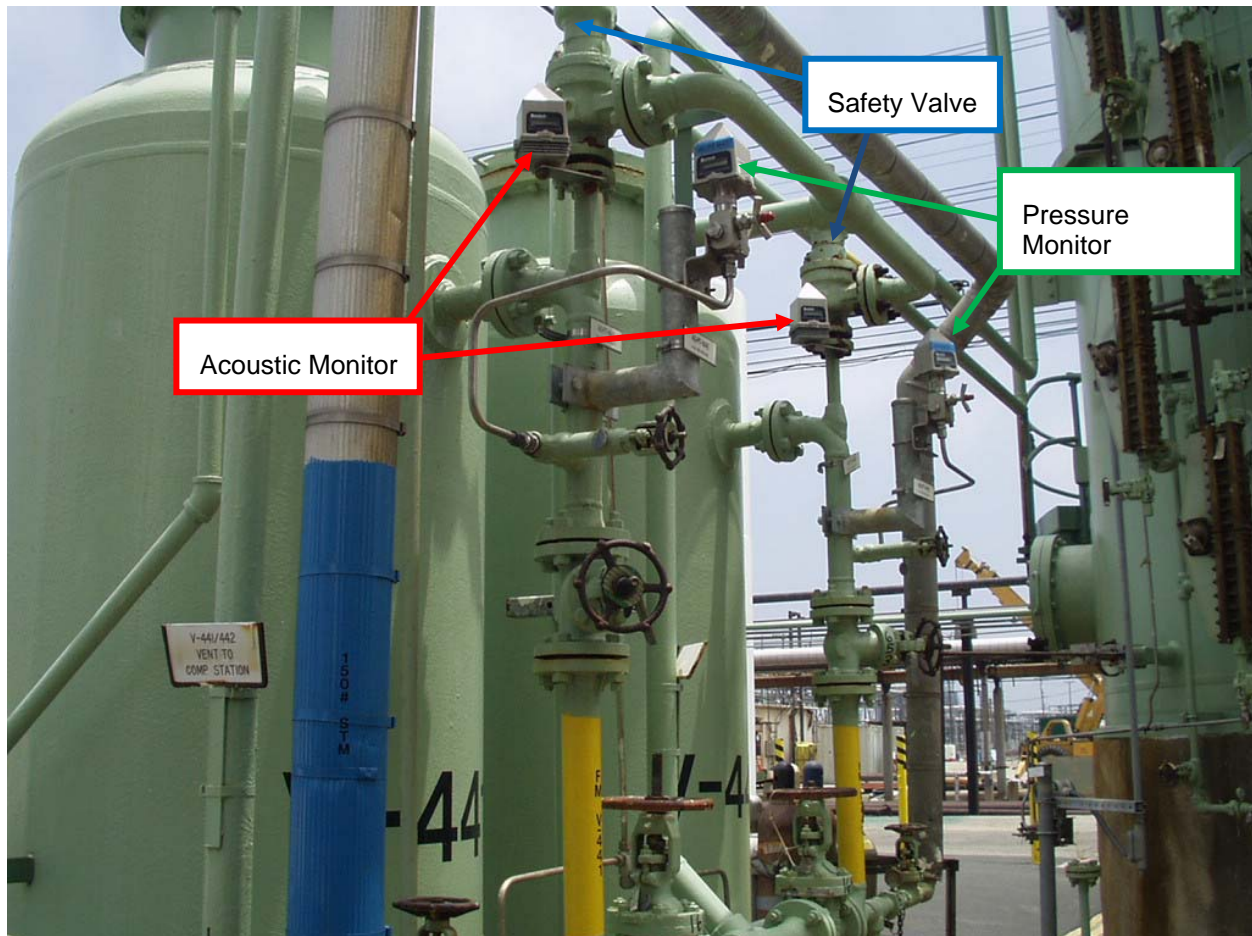
- Class I, Div 1 Rated
- Non-invasive installation
- 10 year battery power included
- License free FHSS
- Proven effective monitoring
- 1000 feet range to base radio
- NO FIELD WIRING for power or signal
- Portable for rapid deployment

CONTROL MICROSYSTEMS

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While ultrasonic sensors provide a versatile, low cost method for detecting leakage, flow and release events, they are unable to distinguish the ultrasonic activity generated from leakage or flow from spurious noise that is generated by mechanical equipment in close proximity to the valve being monitored. The most effective combination of sensors for valve monitoring includes system gauge pressure at the valve inlet plus an acoustic sensor on the valve body. This combination provides additional data that confirms spurious mechanical noise as non-release events. If a short duration acoustic event occurs with no corresponding drop in pressure, then it is verified that pressure release has not taken place. Furthermore, with continuous pressure monitoring, it is possible to accurately calculate the mass discharged during a release event. A typical installation utilizing the combination of sensors is shown below.

If acoustic activity above the normal background level is sustained without a corresponding drop in pressure, then it is an indication of valve leakage. The severity of leakage can be determined by evaluating the magnitude of the ultrasound level in conjunction with the valve inlet pressure. At higher pressures, the flow and the ultrasound level will be correspondingly higher. Low pressures, below 30 PSI do not generate significant ultrasound for leak detection.



Installation using acoustic and pressure Wireless Instruments

Continuous Monitoring Versus Periodic Inspection Detection

As discussed in the overview, the established method for detection of internal valve leakage is time-based shop evaluation with intervals based on operating and inspection history. Portable inspection equipment has been developed that enables periodic in-situ inspections. While this equipment can provide point-in-time evaluation of valve condition, operation of the equipment and interpretation of data requires special training. Also, this technique only provides status at a single point in time and must be repeated frequently to be effective. In large plants with many pressure relief and isolation valves, continuous monitoring is a more effective method for identifying leaking valves than time based inspections. Unfortunately, the cost to install wired monitoring sensors to multiple safety valves in a major production plant can be extremely expensive. Wiring monitoring sensors entails the cost of running the wires to the switches in the field, often through areas classified as Class I, Div 1 or Class I, Div 2. Wired sensors also entail the expense of dedicating individual discrete inputs into plant DCS systems. These costs rapidly add up. One recent facility estimated the costs for wiring pressure relief valves to be over \$10,000 per point.

The rationale for using wireless monitoring for pressure relief valves is two-fold. First, the cost of running the field wiring is completely eliminated. Per point monitoring costs are reduced by 75% to 90% using wireless sensors compared to hard wire. The second reason is to dramatically lower the number of input points to the plant DCS, while, at the same time improving the monitoring capability of the equipment. Input to DCS systems is expensive. With wireless monitoring, blocks of valves can be monitored with a single discrete contact into a DCS system. The exact location of the leaking valve can then be pinpointed with a stand-alone personal computer running the Accutech Manager software.

Guidelines for Valve Monitoring with Acoustic Sensors

Although each plant and valve location within the plant will have different characteristics, some general rules can be established for the use of wireless acoustic sensors.

First of all, the sensing technique is most effective on gas and vapor service or with flashing liquids. Although liquid flow generates ultrasound at higher pressure and flow rates, liquid leakage cannot be detected with ultrasonic sensors. Application of acoustic monitors for leak detection should be limited to only gas, vapor and flashing liquids.

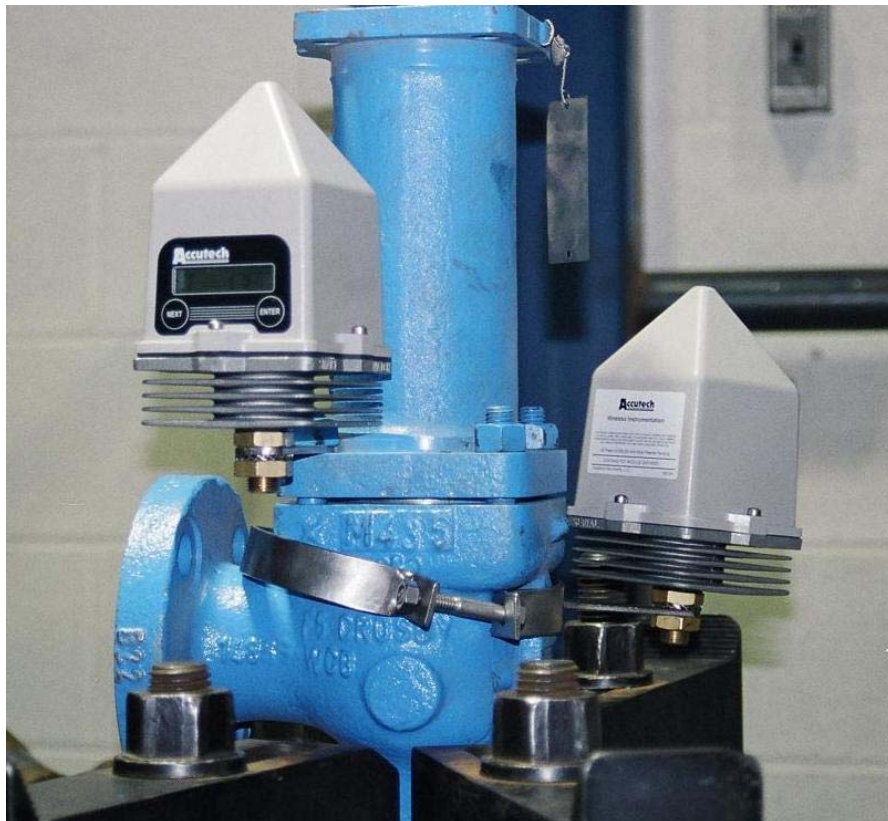
All industrial environments are noisy by nature. Noise activity can be continuous or intermittent. As we have reviewed, valve leakage, once initiated is a continuous noise activity. Therefore, it can be distinguished from intermittent noise by employing filters of ultrasound magnitude and duration. In some equipment locations, there may be continuous ultrasonic noise induced by flow or other operating equipment. In these cases, the magnitude filters may or may not be effective, depending on the level of ambient ultrasonic activity.

Normally, process vessels have limited ambient levels of ultrasound, however process piping may have high levels, particularly at control valve reducing stations, orifice plates, pipe bends or tees where high flow rates are part of process conditions.

- Minimum pressure drop across the orifice must be 30 PSI in quiet locations (no background ultrasound)
- Minimum pressure drop across the orifice must be 50 PSI for normal locations (low levels of continuous ultrasound)
- Minimum pressure drop across the orifice must be 70 PSI for locations with moderate and intermittent ultrasound.

The sensor must be attached firmly to the valve body that is being monitored by means of a sturdy mechanical bracket. A simple straight universal bracket can be used, attaching the sensor the valve with

an existing stud and nut that is part of the valve or outlet piping. The most sensitive location would be threaded into the relief valve adjusting ring retaining screw. This attachment method requires the installation of a modified valve part to accommodate the sensor. Another acceptable method of attachment is using split clamp brackets around the valve body or angle brackets firmly in communication with the valve body using sturdy adjustable clamp rings.



Examples of Acoustic Monitor Mounting Brackets

Once the sensor is installed, a sample of ambient ultrasound level should be observed on the sensor display. Continuous sampling should be employed, so the sensor should be configured for a 1 second sample rate. It is recommended that the alarm threshold for leak detection be set at a level 20 counts above the normal ambient level. It is also recommended that a time filter of at least 30 seconds be set to avoid intermittent noise activity from activating a leak alarm. If the acoustic sensor is also intended to be used for measuring the duration of overpressure events, a secondary (or primary) alarm setting may also be established with a threshold of at least 100 counts with no time filter.



Field Installation Using U-Bolt and Angle Iron Bracket

Note: Preferred mounting location is directly on valve body

In locations where ambient ultrasound is normally above 50 counts, an alternative sensing technology should be employed for valve monitoring. Depending upon the installation design, wireless temperature, pressure or discrete input sensors are alternative monitoring options that will interact with the same wireless sensor network.

Alternative Sensor Options for Valve Monitoring

We have already discussed the application of wireless pressure for valve condition monitoring. This sensor is very effective for determination of release events. Pressure sensors can be applied either on the inlet (upstream) or outlet of a pressure relief valve. The advantages of pressure sensing are positive verification of actual system pressure and the elimination of the need to filter spurious noise from the monitoring data. The downside to pressure sensing is its inability to detect leakage effectively. An excellent application for pressure sensing is high pressure pilot operated relief valves on interstate gas pipeline compressor and metering stations.

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Due to very high flow rates, it is common to have high ambient levels of ultrasound, particularly directly downstream of booster and reducing stations where high turbulence exists. Because pilot operated valves employ elastic seats and the upset ratio increases sealing force as system pressure approaches valve set pressure, leakage is uncommon with this valve construction. Wireless pressure sensing in valve outlet piping provides positive indication of release events as well as time stamps and duration. The figure at right depicts a pilot operated pressure relief valve at a natural gas pipeline compressor station. The wireless pressure sensor transmits alerts when pressure release occurs.

Application of wireless sensors provide continuous monitoring in unmanned areas without the need for any power or signal wiring to the monitored equipment. As pressure relief valves typically have no instrumentation or power this approach provides significant cost benefits in avoidance of material and labor to run conduit, pull wires, dig trenches as well as permitting and documentation expenses.

Another non-intrusive sensing approach to valve monitoring is to use a surface mounted temperature sensor on valve outlet piping. This technique is effective when process temperature varies significantly from ambient temperature. The temperature sensor can detect leakage or release, but cannot distinguish between the two events. It is also effective for all fluid phases. Low temperature processes such as LNG and high temperature process such as steam generation are examples of applications where wireless temperature sensing can work well.

Another wireless instrument that can automate valve monitoring is the multi-input field unit. This instrument is designed to accept two analog and two discrete (contact closure) inputs. There are a variety of valve monitoring applications for this device including:

- Position verification
- On/off condition monitoring
- Rupture disc burst monitoring

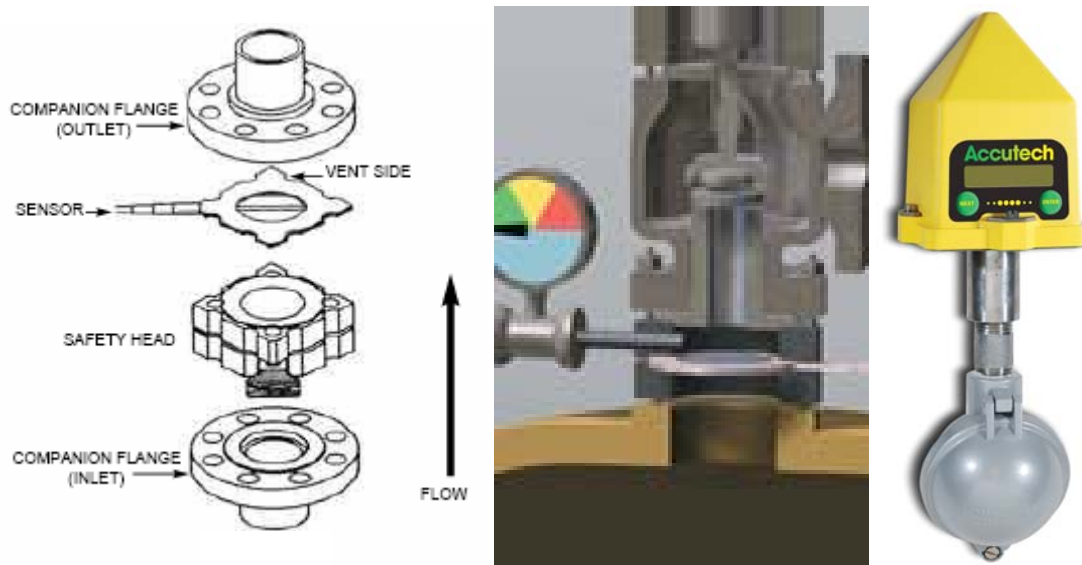


Wireless Pressure Instrument

(Note: preferred mounting of sensor is vertical)



Example of Multi-Input for valve on/off position verification



Components for relief valve isolation and burst monitoring

Given the wide variety of operating environments and installation considerations, this group of sensor packages provides the capability to continuously monitor remote valves that do not have inherent instrumentation or power infrastructure. A summary table of available sensors and suitability for applications is presented below.

**Recommended Sensor Table
Valve Monitoring**

Application	Acoustic	Outlet Temp	Outlet Press	Inlet Press	Acoustic + In Press	Switch
Gas/vapor or flashing liquid – Leak detection	2				1	
Quite area > 30 PSI	2				1	
Normal area > 50 PSI	2				1	
Noisy area > 70 PSI	5		2	2	5	
High turbulence piping	5		2	2	5	
Any application < 30 PSI						
Any fluid with process temperature < or > 50 degrees versus ambient		1				
Any fluid with isolating rupture disc and burst indicator						1
Gas/vapor or flashing liquid – Release detection	2				1	
Quite area > 30 PSI	2				1	
Normal area > 50 PSI	2				1	
Noisy area > 70 PSI	5		2	2	5	
High turbulence piping	3		2	2	2	
Any application < 30 PSI		2	2	2		

1=Excellent, 2=Good, 3=Fair, 4=Not Recommended 5=Unsuitable

Wireless Instrument Network Integration to Existing Plant Systems

The Accutech AM10 Acoustic Monitor field unit may be installed in Class I, Div 1 or Class I, Div 2. The AM10 relays the status of the valves back to a central base-radio where the emergency station location is tagged and identified. Each base-radio may monitor up to 100 valves. The output from the base-radio is a digital data stream in an RS-485-based proprietary or Modbus protocol format requiring just two output wires for data. Each base-radio, in-turn, may be tied into the Accutech 8SW digital output module which has eight switch closures that can be programmed for multiple events. One output switch, for example can be tripped when any valve alarm condition is activated. This single discrete switch closure can be fed into the DCS system to activate an alarm for the operator. This setup requires just one DCS contact to effectively monitor 100 valves.

The network can be expanded to a total of 16 base radios covering various operating units, providing the capability to continuously monitor up to 1600 points.

TSN03892 - Technical Support Notice – Accutech – Valve Monitoring Guideline.pdf

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Technical Support: Available: Monday to Friday 8:00am - 6:30pm Eastern Standard Time

Direct Worldwide: (613) 591-1943

Toll free within North America: 1-888-226-6876

Email: technicalsupport@controlmicrosystems.com